Prometheus, 2015
Vol. 33, No. 1, 21–41, http://dx.doi.org/10.1080/08109028.2015.1060702

Routledge
Taylor & Francis Group

RESEARCH PAPER

Restoring the primacy of technological innovation

William Kingston*

School of Business Studies, Trinity College Dublin, Ireland

The industrial revolution depended upon a system of individual property rights which was unusually capable of forcing self-interest to serve the public good as well. This system led to unprecedented growth of wealth, primarily because it encouraged technological innovation. Over time, however, the laws of property (notably those relating to the corporation and to information protection) were captured by those who could benefit from them. In particular, financiers were released from the disciplines which had applied to them since the invention of money, and this made investment in financial innovation more attractive than technology. During the first part of the industrial revolution, growth in credit meant growth in wealth, but there is now a mass of empirical evidence that this correlation has turned negative. A series of proposals for reversing this trend is offered, specifically changes in corporation law and new means for protection of information. These include measuring grants of privilege by money instead of time, compulsory expert arbitration of disputes, and protection of innovation directly instead of indirectly, which is all that patents purport to offer. It is also argued that public provision of finance for innovation should generally follow a US model (which is described) rather than the practice of the EU, and that funding of university research should be transmitted through firms to a much greater extent than at present. A variant of an earlier Central Policy Review Staff experiment in the UK is suggested as offering some chance of introducing these reforms in the face of politicians' vulnerability to interest pressures.

Introduction

The industrial revolution was made possible only by a developed system of individual property rights which had their roots deep in European culture. Matthew Boulton, the revolution's archetypical entrepreneur, for example, was secure in his ownership of his button factory in Birmingham and its profits. And when he decided to develop James Watt's separate condenser invention, he could also rely on Watt's patent to mitigate the uncertainty and risk of his investment. This was what put the energy of fossil fuels at the disposal of mankind on a large scale for the first time.

The beneficial power of individual property rights arises from their capacity both to motivate the greatest possible number of individuals to act in their own interest, and at the same time direct these actions towards the public good. Rights of this kind can therefore be said to *civilise* self-interest, but they need not necessarily do so. It does not take long for individuals to grasp that the way to escape from the discipline which such rights impose on them, is to get control of the laws which shape property. This is why John Stuart Mill (1862, Book II, Chapter 1) could write that 'the laws of property have never yet conformed to the principles on which the institution

*Email: wkngston@tcd.ie

of private property rests'. There is evidence that capture of laws by interests have made them conform progressively less to these principles since he wrote, and this evolution actually provides a persuasive interpretation of the industrial revolution's more recent history.

Interests were able to increase their power over law-making for two main reasons. Walter Bagehot (1881, p.89), a perceptive political commentator in the nineteenth century, noted that 'half-educated men who have but a single pursuit' (their self-interest) were in the van of this process, but they were kept in check by 'the close vicinity of an educated world'. The values of that world influenced laws at that time mainly through the civil services, the best of which could be objectively described as being 'supremely competent, utterly incorruptible, completely independent of politics' (Schumpeter, 1942, p.346). Public bureaucracies of this kind did not survive World War I. In Britain, the primary cause was officer casualties, and on the Continent, it was post-war inflation. Those who staffed ministries after the war lacked independent means or alternative careers, and consequently had much less ability to articulate the public interest in resisting self-serving pressures, now increasingly mediated through politicians.

Politics was indeed the second way in which interests gained control over law-making, because widening of the electoral franchise made it progressively more expensive to be elected. As these costs increased, politicians became correspondingly more vulnerable to those who could provide the money for their parties' organisation and their campaigns, so that:

> We may observe a notable expansion in the range and extent of collective activity over the last half-century – especially in that category of activity appropriately classified as differential or discriminatory legislation. During the same period we have witnessed also a great increase in investment in organized interest-group efforts designed specifically to secure political advantage. (Buchanan and Tullock, 1962, p.269)

Indeed, one of the most intractable problems of the modern world is how to reconcile universal suffrage with sound economic development.

Corporation law

The evolution of the corporation with limited liability shows clearly how interests progressively developed power to shape property laws. Before the introduction of this institution in a general form, the only way in which a few investors could join together to finance a private project was by forming a partnership. This is a great deterrent to risk-taking because each partner is jointly and severally responsible for the liabilities of the project, without limit. Once the law made it possible to be liable only for the amount each had actually invested, the individual was separated from the corporation in which he had a shareholding, and fear of bankruptcy was largely eliminated. By reducing risk so drastically, this piece of property rights legislation provided an enormous boost to investment, not least in technological innovation. It became the law in Britain in 1855, and then spread to every country in Europe within 10 years. In the US, state after state adopted it during the next half century. Its arrival in France is an interesting illustration of how interests can shape property laws. Because incorporation with limited liability enabled British firms to achieve economies of scale and lower costs, they could export to France and undercut

manufacturers there. Naturally, these quickly persuaded their government to pass similar legislation to enable them to compete again on equal terms (Ripert, 1946, pp.59–62).

Further pressure from interests then obtained two highly damaging additions to corporation law. First, once shareholders were allowed to be intermediaries, such as a pair of clerks in a law office who have agreed to transfer their shares to another when required, the share registers on which the law insists are worthless, because no-one can know any longer who the actual beneficiaries of a corporation's activities are (Bakan, 2004). The entire international tax evasion industry depends upon the total anonymity which this privilege confers. By their ability to keep their profits free of national taxation regimes, firms which operate across borders are able both to compete unfairly with national firms and to use pricing policies which prevent the initiation and growth of competitors. The modern corporation is an essential component of globalisation, a process which massively increases the value of ownership and decreases the returns to labour. Firms which outsource production to countries with low labour costs can both increase their profits, and prevent wages in their home countries from rising. This market power held by corporations is a fundamental cause of the economic inequality which is of so much contemporary concern, exemplified by the attention given to Piketty (2014).

Financiers' liability

Harmful as corporate anonymity is, it is still less so than another change, which was to allow incorporation with limited liability to be applied to dealings in money. Money is different from everything else that can be bought or sold, because a financier does not have to depend upon external investment or borrowing if he wants to expand his business beyond his own resources. He can do it by making loans beyond his reserves, and continue doing this right up to the point where some external shock causes his reputation to be questioned. However, as the founding father of innovation studies, Joseph Schumpeter, observed, this is actually generating money from nothing. It is so profitable that it is almost impossible to resist, and for most of human history, therefore, dealing in money has been the subject of the most severe sanctions. One of these was outright bans on the taking of interest (usury laws) and another made financiers liable without limit for the consequences of their actions – 'to their last shilling and their last acre', as an old law (Irish Parliament, 1721) put it.

Bankers began to escape from these constraints when the first Treasury Secretary of the United States, Alexander Hamilton, allowed the chartered banks of each state to use the corporate form with limited liability. This removed so much of the risk involved in lending that there was plenty of money available to finance the great economic advances there throughout the nineteenth century. But Schumpeter also observed that an initial wave of investment in productive innovations is followed by a second wave, which this time is one of consumption, over-investment and speculation. This generates a boom which inevitably ends in a bust (1942, p.145) and it was just such an explosion of credit that led to the crash of 1929. President Roosevelt's New Deal then included the Glass–Steagall Act to discipline bankers, but their massive and sustained lobbying secured its repeal in 1999. Limited liability for bankers had been much slower to be granted in Europe; indeed, not until 1879 in Britain. Again, this came about through bankers' lobbying after the failure of the City of Glasgow bank the previous year, which bankrupted most of its shareholders.

The decades after World War II were a new period of remarkable technological innovation in the United States, often resulting in whole new industries whose origins were in wartime public involvement in research funding (Kash, 1989). During these years, banks were still constrained by Glass–Steagall, and could make money only by financing this productive expansion. However, once the act was repealed, they were free once more to turn to the secondary, unproductive, wave of investment identified by Schumpeter. This was reinforced by two factors, the first of which was the great increase in politicians' vulnerability to voters' demands since the productive post-war wave, which added to consumption and to unproductive public expenditure.

The second factor was the threat which the revived freedom to expand credit of the American financial institutions posed to the City of London, where financial institutions remained under restrictions. To meet the challenge, these institutions were progressively deregulated between 1986 and 1997. From then onwards, all the banks of the English-speaking world were free to indulge in a frenzy of credit expansion, fuelled by *financial* invention and innovation. They were quickly followed by others, and the power of computers combined with instant global communication enabled the development of a bewilderingly wide range of financial instruments, such as securitising techniques, mezzanine finance, derivatives and credit default swaps. These generated money from nothing to an unprecedented extent. Through wholesale pyramid selling, investors and the general public were led to believe that asset values would grow indefinitely. All of these devices promised bigger and more immediate profits than technological innovation, and of course, delivered them for a while until the crash of 2008 (see Kingston, 2014).

Empirical evidence

The scale of this change from technology to financial innovation is clearly quantified by figures from the National Bureau of Economic Research in the US: as long as firms in that country were exploiting innovations based upon research during World War II, the financial sector accounted for no more than 10–15% of all corporate profits. At the peak of the recent boom, its proportion surpassed 40%, reflecting a massive shift from other kinds of business, and particularly from technological innovation, to dealing in money (Philippon and Reschef, 2009). Confirmation is provided from the same source in the relative increase in pay of those who worked in the financial services sector in the United States during the twentieth century. The ratio of financial wages to non-farm private wages was negative until about 1960, which in crude terms means that bankers were less well paid than engineers. From then onwards, however, this ratio grew rapidly to a peak of 1.7. These figures, of course, reflect creativity and brain-power following the money away from technology.

There were similar developments elsewhere. Data for almost a century, during most of which the British economy was still largely based on manufacturing, show the assets of its banking sector remaining throughout at about half the level of national income. However, again from about 1960, they began a steep climb to a level of more than five times national income during the recent boom (Sheppard, 2006; Bank of England *Annual Reports*). A feature of this development was a great increase in mergers and acquisitions, whereby firms whose activities had relatively long timescales were taken over and stripped of their assets. The empirical evidence is that these are highly profitable for the financiers who initiate them, but that most of the combinations subsequently fail because the capacity of their component firms

to innovate has been destroyed. An illustration is how Arnold Weinstock was able to bring a high proportion of British engineering production into a single conglomerate, General Electric UK. Many firms fell victim to this skilled accountant because their managements had a long timescale that was adapted to technological innovation, but this was no longer shared by the financial institutions which held the bulk of their shares. Just how much their operating timescale was shortened by this is shown by Weinstock's ruling (confirmed to the present author by the firm's head of research at the time) that GEC's main laboratories at Wembley could work only on projects expected to start moving to production departments after as few as five years. This is appropriate for nothing more than incremental innovation.

It is hard to overestimate the impact of these changes. As long as the main focus of that outburst of creative energy which we call capitalism was on technology, it brought about levels of wealth that had never been known before (see McCloskey, 2010). Once its emphasis turned towards financial innovation, there was a general decline from those wealth levels, as well as the emergence of a huge imbalance of rewards in favour of those who are most successful at manipulating money. And finally, there is now a mass of empirical data which shows that for some time past there has been a *negative* correlation between the volume of credit and economic growth [discussed in Bezemer (2014)]. Work on US data in the National Bureau of Economic Research also shows how productivity growth has slowed markedly since 1970, and even raises 'the possibility that economic growth may gradually sputter out' (Gordon, 2012, p.21).

Capture of intellectual property rights by interests

Capture of corporation laws by interests was not the only reason why technological innovation lost its relative importance. The laws which relate to information protection, now grouped as intellectual property rights (IPR), were also changed by a series of readily identifiable interventions. The first of these was beneficent, because it was made at a time when civil services were still strong enough to assert public good against private interest. The initiative for the German Patent Act of 1877, which played an indispensable role in the industrialisation of that country, came from Wernher Siemens. This partner in the great engineering firm saw that investment to realise the potential of electricity required such a law and then actually went into politics to bring it about (Heggen, 1975, pp.115–18). He did not get all his own way, however, because the civil servants of the time understood that their role was to see that legislation also expressed the public interest, and stood out for this. Siemens would probably have been content with arrangements that protected electrical inventions, but the Act as finally drafted also covered those in chemicals, and this contributed greatly to German dominance of world markets of this kind by the turn of the century.

Subsequent pressures from interests, however, were not similarly counterbalanced. The Paris Convention was set up by the most advanced industrial countries in 1883 to provide mutual recognition of their patents and trademarks. Its principle of 'national treatment' allows states to have any kind of relevant laws they like, as long as these treat citizens of all member states equally with their own. In several countries, local manufacture was required for a patent to be valid, which did not suit firms in America or Britain which were leaders in manufacturing productivity. These wanted to export freely from their home production facilities and so add to their

economies of scale while also being able to protect their products by patents in foreign counties. They began to press for such a change before World War I, and eventually obtained it at the 1925 meeting of the Convention.

The US 1952 Patent Act then brought about a fundamental change in the definition of the invention a patent is supposed to protect, which was subsequently copied all over the world. It came about because judges had traditionally held that a 'flash of genius' was needed in an invention for its patent to be valid. Discoveries in the new and highly promising field of antibiotics could not pass this test, because they were made instead by painstaking evaluation of great numbers of possibilities. Streptomycin, for example, was the result of such work on 10,000 samples collected over decades by Selman Waksman, a soil microbiologist (Kingston, 2000). It is no surprise, therefore, that this initiative for new legislation to bring antibiotics into the scope of the patent system came from pharmaceutical firms. As the attorney who took the lead in drafting the new law wrote later, 'The Act was written basically by [that industry's] patent lawyers … A good 95% of the members [of Congress] never knew that the legislation was under consideration, or that it had passed, let alone what it contained' [Judge Rich as quoted in Federico (1978, Sections 1:10, 11, para. 1.09)].

Laws of trademark registration, which were also internationalised by the Paris Convention, became the basis of all the modern marketing industries, and through the Paris Convention, of the international brand. The value of branding was unquestioned until scientific evidence showed the harm of smoking, after which it might have been expected that registered trademarks would be denied to tobacco products. This has not happened because tobacco interests have made massive efforts to ensure that their power to advertise was not diminished by public health concerns. They have been very successful, using the Constitutional provision for free speech in the United States, and property rights elsewhere (Kingston, 2006).

Early awards of copyright protection in the US were for as short a time as 14 years, with another similar period if the author was still alive at the end of the first one. Over time, publishing interests were able to extend the term to as long as 75 years. Towards the end of the 1980s, some best-selling novels and the most important Disney cartoon characters were due to come out of copyright, and this led to massive levels of lobbying for a new US act to change this to 95 years. Apart from contributions from other sources, 'Ten of the thirteen sponsors of the Act in the House received the maximum contribution from Disney's Political Campaign Committee [which] is estimated to have paid more than $800,000 to re-election campaigns'. The extension was duly passed (Lessig, 2004, p.218).

Copyright also played an important part in the growth of information technology, especially in the period before computer programmes could be patented in the United States, when it was the only means of protecting them available. The question of similar patent protection in Europe revealed huge levels of lobbying of members of the European Parliament, with US firms and the European Commission in favour of patents for software and European firms against (and eventually successful). With the coming of the internet, however, the market power of capability, depending primarily on scale of operations made possible by the corporation with limited liability, increasingly came to provide software protection. This has led to what are close to monopoly positions, such as those of Microsoft's Windows in operating systems, and Google in search engines. Copyright on its own can no longer protect digital material effectively, as the revolution in the markets for popular music shows.

However, nothing reveals more clearly how IPR legislation has come under the control of interests than the way in which the World Trade Organization was established in 1994. In an Annex to the Agreement for this, called the Trade-related Intellectual Property Section (TRIPS), US-style intellectual property laws were universally imposed, even on poor countries which could get little if any benefit from them. TRIPS had been designed and lobbied for by a committee of US firms, to the extent that an historian of the process could accurately write that 'twelve corporations made public law for the world' (Sell, 2003, p.96). The influence of the pharmaceutical and tobacco industries is especially clear in the relevant provisions of this Annex.

Potential reforms: the corporation

The capture of legislation by interests which these examples illustrate, and the shift to financial innovation, are largely a consequence of the vulnerability of elected politicians to those who finance their campaigns, and to the extinguishing by World War I of the 'old' civil services of Europe, which were independent enough to confront special interests in the name of the public good. The following is a series of institutional changes which could contribute to restoring technology to its former importance. They do depend, of course, upon the heroic assumption that some way can be found of reversing the earlier capture of the relevant laws.

In the case of the corporation, the very least that is required is that in exchange for the enormously valuable privilege of limited liability, there should be complete transparency as to who are the beneficial owners of a firm, with the sanction of immediate and complete loss of the privilege for failure to comply. This is not in any sense an interference with entrepreneurial freedom, since it remains open to individuals to cooperate through partnership. Also, the corporate form with limited liability has to be completely denied to financiers. Otherwise, it will be far easier for them to make money by generating it from nothing and using it in unproductive ways, instead of having to face the uncertainty and risk of investing in technological innovation.

It cannot be stressed enough that unlimited liability is the only possible way of making those who deal in money serve the public good. Regulation cannot work; first, because of the vulnerability of politicians to pressures on them to override regulators, and second, because of the huge motivational imbalance among the parties, which leads to what is known as 'regulatory capture'. Financiers' response to any proposal to discipline them in this way would doubtless be to claim that economic disaster would inevitably follow the resulting reduction in the scale of their operations. There is evidence to the contrary. They were able to finance the industrial revolution before they were granted incorporation with limited liability, and this included handling flotations which would be large even by modern standards, such as that of Guinness by Baring's (then still a partnership) in 1888. The evidence from recent years that increased credit correlates with lower economic growth, discussed by Bezemer (2014), confirms that it is not the quantity of investment, but its quality that counts. And quality means investment in Schumpeter's primary wave (technology) rather than in his secondary one (consumption).

Potential reforms: intellectual property rights

To provide opportunities for primary wave investment, there has to be radical reform of intellectual property laws. When the industrial revolution was at its height, Lord

Kelvin observed about engineering (surely with Whitworth's micrometer invention in mind) that 'we advance according to the precision of our measures'. By this criterion, we cannot expect much from any of the present forms of intellectual property because our measures of these, which are all in terms of time, are anything but precise. Copyright is now generally for the author's lifetime plus 80 years, and trademarks can be renewed without limit. A patent lasts for 20 years from application (with a possible extension to deal with the time it now takes for a pharmaceutical discovery to get through clinical trials). These are all very crude instruments for giving a particular innovation the protection it needs to justify investment, which is the only reason for intellectual property laws in the first place.

The crudest of all these measures is the unconditional and perpetual protection which trademark registration confers. This is the source of the monopoly of brand names and consequently of so much of the market power of the firms which own these. It underwrites a huge amount of beneficial innovation, although it must be recognised that this is almost all in Schumpeter's secondary wave, and relates to consumption. All these combined advances, even when combined with those in information technology, cannot substitute for the inventions and innovations needed to deal with global warming, for example.

Firms now consider this monopoly to be their automatic right, even if some of the effects of what they make and sell have been proved to be harmful. There can now be no doubt whatever that tobacco products fall into this category, the power of firms to promote alcohol consumption is being questioned, and the evidence of the connection between food branding and obesity is also building up. It is surely absurd that a patent, which is in force for only 20 years, cannot be granted for anything that is 'against public policy', when no similar restriction is placed on the monopoly of a trademark, which is unlimited in time if renewal fees continue to be paid. In fact, the Paris Convention and TRIPs, reflecting the influence of interests in their drafting, both include the provision that 'the nature of the product shall in no case be a barrier to its [the trade mark's] registration'.

At a level which is not a matter of life and death, as is branding of tobacco products (which kill half their users), it is claimed that cleaning chewing gum from pavements in Britain costs £80 million a year, and the authorities cannot persuade the manufacturers to introduce a biodegradable product, although this exists. There seems to be no reason why the public should have to bear such a cost, and the threat of withdrawal of trademark registration would undoubtedly bring about a rapid change. Indeed, where any trademarked product can be shown to impose a cost on the public, there seems to be no sensible argument against making continued registration of the mark conditional upon its owner's bearing of part or all of these costs.

Potential reform: patents

The patent system's performance record is so bad that it is not surprising that there are calls for the elimination of this form of information protection altogether (e.g. Boldrin and Levine, 2008). This would mean that the only sources of protection for new ideas would be the market powers of capability and persuasion. Both of these depend upon scale of investment, in productive resources in the first case and in marketing in the second. This premium on size gives advantage to firms that are unlikely to invest in radical innovation. Instead, they will deploy their market power to increase profits by operating pricing policies to prevent the foundation and growth

of new firms built by new people on new ideas. Challenges to incumbent firms from these constitute the process which Schumpeter (1942) called 'creative destruction', which is essential for creation of wealth because it is 'the competition that counts'. The shift to financial innovation has made this the exception rather than the rule. The modern example of the demise of Kodak at the hands of its competitors, brought about by its failure to capitalise on its own early involvement in the revolution of digital photography, is quite exceptional. Creative destruction could hardly happen at all without intellectual property laws to enable smaller firms to take initiatives to innovate, however badly these laws perform.

Rather than abolishing patents, therefore, efforts to restore primacy of technological innovation should be directed towards supplementing them with new means of information protection. Two-thirds of all the worldwide profits attributable to patents are gained by chemical inventions (Bessen and Meurer, 2008). All other technologies combined consequently share only the other third, indicating how badly the patent system performs for them. The following three proposals for improving this situation have persuasive support from empirical research (see Kingston, 2010).

Money instead of time as measurement

As well as the drawback of a fixed term of protection, an exclusive right is not optimal for technological inventions. The more important of these have the potential to be developed along several different trajectories, yet a single firm can follow only one of these well. Patent protection as it exists can therefore prevent competitors from following up alternative trajectories to the public's advantage. The patent held by Boulton and Watt held up the development of steam power because Watt could never reconcile himself to the idea that the future was with high pressure, not low pressure steam. There can be no doubt at all that the energy and skill with which the Wright brothers used their patents retarded the development of the aviation industry by decades.

It is a waste of resources for a competitor who wants to develop an invention to have to try to 'invent around' a patent, and of course all infringement litigation is even more wasteful, not just of money, but of talent. In their aero engine case against Rateau, for example, Rolls-Royce had to divert a technical director from supervision of design work for six years. These wastes are an inevitable result of protecting information by what is intended to be a monopoly for a period of time. Of course, when patent and similar laws were first passed, there could have been no other measure than time, but with the development of accountancy, there is no excuse for not changing to the proper measure, which can only be money. Using this, and abandoning the monopoly element in protection, could make investment in innovation vastly more rational and consequently more attractive. Changes can be envisaged which would give an originator firm a better expectation of being recompensed well for a successful investment made under uncertainty and risk. At the same time, other firms would not be denied the opportunity of exploiting the originator's information as widely as possible.

One way in which this could be done is by basing protection on how much an invention or innovation had cost the firm which created it. Other firms which then wanted to use the information could license it by paying prescribed *multiples* of that figure, depending upon how early they apply in the process of risk reduction through innovation. This is *retrospective* sharing of the uncertainty and high risk associated

with an investment which led to useful information, with latecomers paying a premium because they had not invested originally or earlier. Research by this author on 23,000 cases from US Small Business Administration records suggests that multiples could be calculated to put originator and follower firms on an equal basis, depending upon the gap in time between each of their investments (see Kingston, 1994).

It may be objected that it would be difficult to establish an accurate basis for the costs in a firm to which the prescribed multiple would be applied. The counter-argument is that:

> Patent applicants and patentees collect this information anyway for a variety of reasons, including (1) tax benefits, (2) internal cost accounting, (3) use in project evaluation, (4) use in licensing evaluations and the like. Patentees appear to have no difficulty in showing research expenditures at the damages stage of a patent infringement suit … and such information has been introduced in some cases to show the non-obviousness of the invention involved. Simply adding one more reason to collect data on the cost of a research project does not seem to present a major problem. (Merges, 1992, p.55)

Measurement of patent grants by money would have a threefold advantage over the present patent system. First, originator firms would benefit from the increased size of market created by exploitation of their new concept along multiple trajectories. Because their transistor invention was used in so many different ways, Bell Laboratories' decision to license it to all comers for a flat fee of $100,000 probably gained them more – and more quickly – than had they tried to enforce their patent. The more important the invention, the more licences would be sought and the more multiples paid. Second, all the waste of inventing around, and particularly of litigation, would be eliminated because it would not be rational for a competitor to spend money on either when a licence could be bought; and third, the public would benefit from both quicker exploitation of information along different trajectories and from the competition between firms in incremental innovations, which would expand their range of choice. As the markets for the innovations which exploited the full potential of the original invention approached full development, firms would then have to compete on price, to the public's further advantage.

Reducing the costs of dispute resolution

Because owners of any kind of intellectual property have to protect their grants themselves through the legal system, these grants are effectively no more than licences to litigate. Consequently, they only have value to the extent that there are substantial funds available to pay lawyers, and even to risk having to pay the other party's costs in the event of failure. Courts may require the posting of a bond for such costs before a case even starts, so that it will not go ahead if the party concerned cannot afford this. The result is that a firm's valid protection can be infringed with impunity simply because it cannot afford to pursue a wealthy opponent through the courts. Also, rich firms get *de facto* protection that would be found to be invalid if it was tested legally, just because no one can afford to challenge them. This has been summed up by a former manager of technology and strategy at IBM:

> Large firms routinely infringe intellectual property of start-ups or individual inventors. They will not sign non-disclosure agreements to protect others' IP. When shown

> relevant patents they need to license, they literally say 'Sue us', knowing that deeper pockets trump a valid claim. (Schapiro, 2012)

When the state grants privileges, it should police them. This is not only for the sake of justice, but because infringement of a grant which has been made for a public purpose (in this case, national industrial development) is also an attack upon the state's own economic policy. Another problem is that there is no shortage of evidence of how serious a drawback it is for decisions in patent cases to be made by judges who are amateurs in technology. Even in the few specialist courts that exist in the world, such as the Court of Appeal for the Federal Circuit in Washington DC, which handles all US patent appeals, and which has judges with a scientific training, judges cannot possibly be experts in all the issues that come before them.

An obvious solution to these problems exists, and is used for technology everywhere – except for intellectual property. This is expert technical arbitration. It is almost unknown for a dispute on technical grounds between a firm or a public body and a contractor (to build a bridge, for example) to get as far as litigation, because in every case the contract between them will contain a clause providing for arbitration. There is, of course, no contract between a patentee and an infringer, but there is one between the state and every patentee so that the law could be changed to make expert arbitration compulsory, with the courts dealing only with appeals.

It might be argued that this suggestion would only push the deep pocket problem back a stage because firms with resources would appeal from adverse arbitration decisions if they could see that their opponents would have difficulty in meeting the cost of litigation. A simple solution to this difficulty would be to make legal aid available to the party which accepted the arbitrator's decision in the event of an appeal from it. Note that this would not be support for any particular size of firm – it would be available to financially strong and weak firms alike. In practice, though, no weak firm would appeal from a negative arbitration decision because to do so would shift the dispute on to ground where its stronger opponent could use its financial advantage. Large firms would also be reluctant to appeal when faced with the combination of having lost an expert arbitration (because judges give much credence to technical expertise) and of facing an opponent who would then have equal resources for litigation. Legal aid could therefore be expected to be called for in very few cases.

There is now empirical evidence that such an arrangement could be successful in the results from the opinions procedure introduced by the UK Patent Office in 2005. For as little as £200, anyone can now ask for all aspects of a UK patent, including its likely validity when faced by identifiable infringement, to be reviewed by a senior examiner. This is in fact expert arbitration, although of course it is not binding on the parties. There have been about 30 of these opinions each year since.[1]

Their quality is remarkably high, and they may already have had a beneficial effect in reducing wasteful litigation. Predatory firms may now hesitate over using their financial advantage in going to court if an opinion at this level of technical expertise has been unfavourable to them.

Protecting innovation directly (DPI)

The objective of all information protection is to make it rational to invest to turn the information into concrete reality. In most cases, the cost of doing this (innovating) is

very much more than that of generating the information in the first place (invention). However, the patent system only protects invention. Consequently, whatever protection its related innovation receives from a patent depends upon the strength of the link between them. In the case of pharmaceutical inventions, the link is very strong because what is discovered in the laboratory and patented, what succeeds in clinical trials, what is manufactured in bulk, prescribed by a doctor, dispensed by a pharmacist and eventually taken by the patient, are – indeed, have to be – identical. In contrast, between a mechanical invention and its eventual commercial embodiment, there will often be so many incremental changes as to make one virtually unrecognisable from the other. Any doubt about this claim can be easily resolved by comparing Chester Carlson's invention of electrophotography in his 1942 US patent no. 2,297,691 with the Xerox 914 office copier, which eventually commercialised it so widely. This difference between the strength of the links between different kinds of technology is enough on its own to explain why chemical inventions earn no less than two-thirds of all the worldwide profits attributable to patents.

There is no reason why the other technologies should have to depend upon a system which serves them so badly. Their innovations could be protected *directly*, instead of by the indirect protection which is all that the patent system purports to give them. This, in fact, is the way in which investment in developing new varieties of plants has been underwritten since 1961. Plant variety protection is not given for a concept of a new plant, nor even for one that has come through its trials, but only for a developed new variety, reproducible and ready to go on the market. The same approach has been applied to 'orphan' drugs (to treat diseases which have too few sufferers to be of interest to the large firms) in the US since 1982. This has been particularly successful, resulting in no less than 12 times more drugs of the kind required, and measurable declines in death rates from the relevant diseases (Grabowski, 2005). The provisions relating to functional designs and to boat hulls in the British 1988 and US 1998 Copyright Acts respectively, as well as the treatment of databases in the EU from 1986, are also forms of protecting innovation directly.

After Hermann Kronz and the present author had independently published articles advocating DPI, the EU commissioned a book of critical comments on it by international experts (Kingston, 1987). More recently, the idea has been discussed by Sichelman (2010). As the concept has been developed, DPI's criterion of novelty would be 'non-availability in the ordinary course of trade'; it would require actual investment to innovate, and its grants would be irrevocable. Amongst its advantages is that it would protect the innovation of many inventions for which markets or enabling technology were not available when they were patented. Not only were the patents in such cases of no value, but no protection can ever be obtained later, if and when it is needed, because of the earlier disclosure. In this way, DPI would give protection to inventions whose time has come just when they need it. It would not modify nor interfere with existing patent or design arrangements in any way. Nor could any country be prevented from introducing it by its membership of the World Trade Organization, since only types of intellectual property that existed in 1994 are covered by the TRIPS Annex to the WTO agreement.

Finance for innovation

These reforms could transform the attractiveness of investment in technological innovation, but their effect will be limited unless there are also parallel improvements

in ways of providing that investment. Decisions about anything new have to be made at first in the face of uncertainty and only later on do they come into the realm of risk, which is uncertainty quantified. Investment before risk can be calculated cannot be rational, so the very first money that is put behind a new idea – seed capital – has to be invested *irrationally*. This is why it is an axiom in the venture capital industry that the only people who provide money at this earliest stage are 'founders, family and fools'. All three of these, it is clear, are likely to have some non-rational reason for doing so. Much of the industrial revolution was financed in this way by rich individuals who were secure in their wealth, and could be said to have had 'more money than sense' because they were unaware of the distinction between uncertainty and risk. It has even been suggested by an exceptionally experienced innovator that English landowners were able to finance the industrial revolution to the extent that they did because they were used to betting on their own horses (Norway, 1954).

Over time, however, three factors – expropriation, taxation and the growth of accountancy – have gone far to extinguish this kind of funding of invention and innovation. The combination of the first two put an end to rich individuals' ability to feel that their wealth is secure. No rich person now feels confident of staying rich without the advice of expert accountants, and this advice can never be other than to invest *rationally*. No professional financial advisor could ever recommend investment, for example, in invention or the early stages of innovation. Although individual angel investors do sometimes fill the gap between seed and venture capital, their aggregate contribution remains small so that the most common large-scale sources of money for early stage investment now have to be either the retained earnings of large firms or the state.

Retained earnings are inhibited from being invested in technological innovation because of the constantly increasing pressure from shareholders for earlier returns, especially if these are institutional investors, such as pension funds, which have the alternative of switching to financial instruments. It is this which has shortened firms' time horizons generally, just the opposite of the patient waiting which technological innovation needs. The now widespread payment of executives through stock options reinforces this development because it aligns the interests of firms' managers with those of stock traders, who are primarily concerned with calculable risk and short-term returns (Lazonick, 2009). The attraction of investing in anything other than incremental innovations in their existing product lines is low for most large firms because it involves uncertainty as well as risk, and even if it is successful, its results will appear only over a considerable time.

Public funding of research

Lack of private sector investment in innovation has led to public funding of research, but unfortunately this involves bureaucratic direction. Civil servants, as well as politicians, have poor understanding of the innovation process and tend to see it in a simplistic linear way: investment made in fundamental research, they think, will lead in some cases to applied research, and some results from this will then result in high technology businesses generating employment and taxes. In practice, the relationship between science and technological innovation is quite different. Fundamental research rarely leads to anything that can be commercialised, even over the medium term. Much more often, the need for basic science is because decisions are made to

innovate and it is subsequently discovered that progress cannot be made without more theoretical knowledge. The world's first commercial jet airliner, the de Havilland Comet, for example, was well into service before its catastrophic crashes and the subsequent research into their cause revealed that not enough had been known about metal fatigue at the design stage.

The shift from technological to financial innovation has stimulated many governments to increase public funding for research greatly in the hope that this will mitigate unemployment. The main beneficiaries of this have been universities, and this expansion of their research funding coincided with a particular US development that was copied worldwide. Up to 1980, if a patent resulted from publicly-funded research, it belonged to the government. From that date, researchers and universities were allowed to own these patents. The Cohen–Boyer gene-splicing patent then brought huge sums in royalties to Stanford University, and many universities thought that they, too, could become rich by patenting their research output. The results could hardly have been more disappointing, with only very few universities even being able to cover the costs of the technology transfer offices (TTOs) they established (Mowery *et al.*, 2001). Government subsidy of university research has not resulted in the new products, new businesses and new employment that were hoped for. Some TTOs have even (unwittingly or otherwise) assisted firms (known as 'Trolls') whose business is using patents to blackmail genuine innovators.

Micro *versus* macro research

This outcome is in line with many international comparisons of the results of research and development which show that the leading countries are those in which the highest proportion of research and development (R&D) spending is by firms, rather than by public authorities. Inter-country comparisons have shown over a long period that the direct use of public funds for R&D is less effective for wealth-creating innovation, than is research funded by the private sector:

> … private R&D expenditures (as % of GDP) higher than public ones (over 1998–2004) seem to be one of the main determinants of increases in labor productivity per hour worked (over 1999–2005). (Coccia, 2012, p.377)

A contributory explanation for this is that firms have precisely defined objectives for their expenditures, and their budgets leave little room for deviations from these objectives, no matter how attractive these by-ways appear to be. Their research is at the micro level. In contrast, publicly-funded research tends to be macro, with objectives that tend to be broadly and loosely defined. In such a context, exploring interesting new avenues, which inevitably arise during the course of the work, can be easily tolerated. Weiss (2014) has stressed the strict focus of the US$3 billion annual budget of DARPA (the Defense Advanced Research Products Agency) of the United States, but this is quite unusual. It does not contradict the general experience that subsidising science tends to lead to more science, not to more innovation.

Two other factors reinforce this. First, macro programmes are administered by public employees, who naturally shun uncertainty and also favour programmes whose timescale to judgement is long, so that they can avoid responsibility for failures. This, and not just the desire of both French and British politicians to save face, was surely a factor in the repeated extensions of the Concorde project against all the

cumulative evidence. Second, external experts on panels which decide on public awards for R&D tend to come from universities rather than industry, partly because of the danger that the latter might obtain information about their competitors' projects, which might deter these competitors from submitting proposals. Academics are trained to think in macro terms, so that it could be there is less possibility of a meeting of imaginations between them and those they are assessing, who are more likely to think in micro terms.

Consequently, if the primacy of technological innovation is to be restored, much of the funding that currently goes to universities and public research institutes, and thus mainly to macro research, must be directed instead towards firms and micro research. There is no need to look for a model for this beyond the highly successful Small Business Innovation Research (SBIR) programmes of the United States. These currently dispense nearly US$3bn a year in competitive awards, a significant proportion of which ends up as payments to university departments for research which the awardee firm does not have the resources to conduct itself.

The US SBIR model

These programmes were established through a 1982 Act directing US public agencies which spend over $100 million annually on external research contracts to divert a small proportion of this funding (currently 2.6%) to an SBIR programme. Moreover, they must do this according to detailed provisions for a competitive three-stage system, the first of which gives awards for up to $150,000 and six months' work, and the second up to $1 million over two years. Firms are allowed to spend one-third of a first-stage award, and half of a second-stage one, on supplementing their own knowledge and resources. This generally means sub-contracting for university research, where the firms' concern with commercialisation keeps the focus of the academic researchers on the task in hand, at a level they would not match on their own. These two stages provide enough money to squeeze uncertainty out of a new concept so as to enable venture capitalists to make rational decisions about investing in its innovation (on a basis of risk) in the third stage of an SBIR programme.

The manifest success of SBIR has led to attempts to copy it in such countries as the UK, Netherlands and Sweden, but the concept appears to be unusually difficult to transplant. European countries, and the European Commission itself, have found it impossible to copy a crucial feature of the SBIR model, which is that its awards are given with both hands. This means that the research, including the firm's overheads, is *completely* funded by the state. In fact, the figure is more than 100% of an awardee's costs because 7% of it does not have to be accounted for in recognition of the cost of distraction of the firm from its normal activities.

The European preference is to fund much less than the total cost of a research project on the grounds that if a firm is making its own contribution, its management has more faith in the project. This ignores the reality that having more or less belief that an investment will succeed is a matter of being able to calculate its risk. There can be no rational belief at all until uncertainty has been reduced to risk. The projects that will get funding on this European basis will therefore be those with lower risk (greater faith on the part of their proposers). Those which involve uncertainty (that is, before there is enough information available to calculate risk) are unlikely to be funded.

European copy of SBIR

This bias against projects which involve uncertainty is evident in the EU's new research funding programme up to 2020. Its authorities have been under pressure for many years to offer something comparable to SBIR and in the new SME instrument (SMEI) of this programme, they have at last attempted it.[2] The objective is 'to help high-potential SMEs to develop groundbreaking innovative ideas for products, services or processes that are ready to face global market competition'. At only €3bn in total over seven years, the amount is small compared with the almost $3bn of SBIR each year, but it is a start. Concern about its likely effectiveness relates to factors other than its size.

The European scheme is not limited to technology as SBIR is, but in spite of this wider scope, it is hard to see how it can have anything like comparable success. It is intended to support 'close-to-market activities, with the aim to give a strong boost to breakthrough innovation'. These are incompatible objectives: 'breakthrough innovation' is invariably a very long way from 'close to market' activities. Indeed, it looks as if SMEI will not be of much help to invention and early innovation, as comparisons with SBIR illustrate. Both have two stages, the first for a feasibility study, and the second for the main research. SBIR Stage 1 offers 100% of all costs including full overhead, of which 7% does not have to be accounted for, as noted above. SMEI, in contrast, requires the firm to put up 30% of the cost (the conditions explicitly state that the maximum award of €50,000 can be awarded only in respect of total expenditure of €71,249). In Stage 2, it can offer 100% if the research content is 'exceptional'.

Perverse incentive

This EU incentive is perverse, because Stage 1 relates to the condition of maximum uncertainty about the outcome of any investment. This author's research on a large number of SBIR awards, referred to earlier, shows that the chances of a proposal going through both stages, obtaining venture capital and ending up as a product on the market within seven years were well over 100/1, and the odds in Europe are likely to be even greater. Since SMEI will provide only 70% of the cost, any offers it may make are therefore tempting owners of small firms to invest up to €21,000 of the firm's own money, not just at extremely long odds, but under uncertainty (that is, before odds can be calculated at all).

This is unethical, because small-firm innovators are vulnerable to this temptation from their irrational belief in their own idea. It is also unproductive. On the basis of the empirical results just cited, all but a tiny fraction of the money put up in Stage 1 to match that of SMEI will be lost. Innovators who have had to contribute 30% are consequently unlikely to have the resources to try again, nor will they want to. The gloomy view of financial experts that pioneering does not pay will be confirmed. In contrast, SBIR's 100% funding (including full overhead and 7% for 'profit') leaves the small-firm innovator's own funds intact, with no disincentive to repeated attempts to innovate. In fact, the structure of SBIR specifically includes built-in encouragement of multiple applications, both to different agencies and over time. Successful innovation is about learning from failure, so that public funding should enable innovators to discover whether their idea is going nowhere as quickly and cheaply as possible so as to free them to move on to the next one, which is likely to be better.

The success of SBIR doubtless owes much to the number of decision points it offers in that there are 11 agencies in the scheme, some of whose research interests overlap. The beginning of all economic innovation is a meeting of imaginations. It can be nothing more than this because at the outset there can be little factual data on which to rely. Since all our imaginations are limited, the chances of such a meeting increase with the number of decision points. They are lowest where there is only a single one, as SMEI has. The evident flaws in the design of SMEI make it clear that Europe still needs its copy of SBIR, and that its new scheme will do little to enable its smaller firms to innovate to anything like their potential. Only a much more radical adoption of the ideas that have proved to be so successful in the United States can achieve this objective.

Could bureaucracy help?

If the funding aspect could be improved, and the laws which have a bearing on innovation were changed along the lines suggested above, the balance could be expected to move back to technology from innovations in finance. John Maynard Keynes (1936, p.386) ended the most influential book on economics of the twentieth century by claiming that 'in the last analysis it is ideas, not vested interests, which are dangerous for good or ill'. However much those who are concerned with innovation might wish this were true, interests have so greatly increased their influence over the political process since he wrote, that it is now only possible to feel nostalgic about his claim. The cost of elections in advanced democratic societies has become so great that it is too much to expect that any politician, much less a political party, could think of doing anything other than responding to the interests which fund them.

However, although it is now much weakened, there is another component in policymaking, which is the public bureaucracy. It may seem strange to suggest that help might be forthcoming from this source, the growth of which is widely blamed for sclerosis in economies. This growth depends upon 'belief in the superior wisdom of the State', which, as Soviet Russia and Eastern Europe showed, 'breeds pathologies which deform, and at the limit destroy, the economies based on it' (Skidelsky, 1995, p.xiii). Those economies which practised collectivism were unable to innovate outside a narrow range of fields. Indeed, bureaucracy and innovation are mutually incompatible, since all innovation involves ignorance and uncertainty, whereas bureaucracy can operate only on a basis of established information. No matter how polite the surface exchanges between them may be, bureaucrats fear innovators because they are disruptive, and innovators in turn are convinced that bureaucrats are incapable of sharing their imaginations.

It is not impossible, however, that this antagonism could be partly reconciled by focussing on the laws which facilitate innovation, or fail to do so, because drafting laws is essentially a bureaucratic task. The enormous advantage of the individual property laws in force during much of the industrial revolution was that freedom under them allowed the widest possible range of individual creativity to obtain backing to turn ideas into concrete reality. It has been noted earlier how the German civil service acted in the public interest in re-casting some of Siemens's ideas about the content of the 1877 Patent Act. Much more immediately, the US Small Business Innovation Act of 1982 was the direct result of an initiative of a remarkable civil servant, Roland Tibbetts. He originated the concept, tested it in the National Science Foundation where he worked, and obtained the political support it needed. In the

process of innovating his concept of SBIR, Tibbetts had to withstand much bitter opposition, the most intense coming from universities, which saw some of what they considered their rightful funding being diverted to industry. When SBIR did become law, it was only by a single vote, although its success ensured enthusiastic support from legislators at subsequent re-enactments. Through all of these, Tibbetts's original formula has remained substantially unchanged.

The lobbying for laws to benefit individual interests which Tibbetts had to withstand has, of course, increased greatly even since his time, and the power of bureaucracies to resist it has also lessened. Lobbying now employs more people than any other industry in Washington DC, and the situation in Brussels, as the capital of the EU, is little better. It has even been observed by a former Deputy Governor of the European Investment Bank, that:

> One of the most remarkable shifts in European economic policy governance in the last decades has been the evolution from a 'social partners' approach to a lobby-influenced approach of economic policy. (Nowotny, 2004)

Brussels is a special case because for all the power and money it deploys, the EU's bureaucracy is not a large one. This means that the length of time any senior civil servant spends in one post is short (and may have been shortening over time). Indeed, it seems that the most able ones have hardly had time to master their brief before they are promoted, leaving their replacement to begin the learning process all over again. This leaves an informational vacuum which lobbyists, who by definition are completely on top of their briefs and single-minded about their objectives, are equipped to fill, and enthusiastic to do so.

Continuing education for civil servants

Modern civil servants are not provided with the alternative educational resources which would equip them to process effectively in the public interest, the information showered on them by lobbyists. Any continuing education they may receive is likely to use models from business and industry, which are fundamentally wrong for the public service. They are almost never to be found at conferences which could help them, and leave of absence to study under the world experts who could give them the guidance they need is almost unknown. Instead, their abilities are almost solely used in expanding the process of intervention in the economy, rather than in analysing the root causes of problems and drafting laws – especially laws of property – to deal with them.

This is why the classic bureaucratic response when something is found to be wrong invariably avoids going to the root of it. Doing so would affect vested interests, some of which may be perceived to be able to affect senior public servants' career paths through political influence. The standard procedure is therefore to leave the basic problem untouched and to institute or expand some form of regime to pretend to deal with one or more symptoms. This also has the advantage of generating more opportunities for promotion. Not surprisingly, worldwide evidence is that such arrangements fall under the control of the interests against which they are directed. This is 'regulatory capture', of which there is no better illustration than the utter failure of bureaucrats to deal with bankers, once these had escaped from the only discipline they ever respected – legal responsibility without limit for their failures.

Central Policy Review Staff

Nevertheless, since nothing can now be expected from elected politicians, civil servants remain the best hope for restoring the primacy of technological innovation. One final suggestion may therefore be made, since the basic problem is to secure laws of property that reflect the interests of the public, and not only private interests. This is a modified version of a remarkable political experiment in the UK for which the scientist Lord Rothschild was responsible. Rothschild was convinced that the growth in volume of public administration, caused by the determination of politicians to intervene in the economy, left higher civil servants without time to understand and reflect upon long-term policy issues, much less to develop adequate proposals to address them. His solution was the Central Policy Review Staff (CPRS) in the Prime Minister's Office, with a brief 'to think the unthinkable' (see Blackstone, 1990).

However, there was a practical flaw in Rothschild's concept in that it was seen by individual government departments as external interference, and resented accordingly. Their resulting failure to cooperate brought it to an end. His vision might succeed, however, if it was revived in the form of an elite group *within* each government department. The sole task of each of these groups would be to draft either amending or new legislation for every issue that arises, which would offer a clear alternative to both interest-driven laws and bureaucratic intervention. There is just a chance that something along these lines could deliver the same kind of public interest counterbalance to private interests as the old bureaucracies of Europe did until they were destroyed by World War I. To the extent that this happened, there could be a return to one of Schumpeter's productive waves of investment, which would head off the move to collectivism in reaction to so-called 'free market' or 'neo-liberal' economics, which is actually the economics of interests. If we can get the laws of property right, in however limited a way, wealth is bound to follow, just as it did in the earlier stages of the industrial revolution. But, in the face of the scale of interests that now finance election campaigns, there must be serious doubt that the political will for this change now exists anywhere.

Disclosure statement

No potential conflict of interest was reported by the author.

Notes

1. Published at https://www.gov.uk/government/collections/requests-for-opinions.
2. See https://ec.europa.eu/programmes/horizon2020/en/h2020-section/sme-instrument.

References

Bagehot, W. (1881) *Biographical Studies*, Longmans Green, London.
Bakan, J. (2004) *The Corporation*, The Free Press, New York.
Bessen, J. and Meurer, M.J. (2008) *Patent Failure: How Judges, Bureaucrats and Lawyers Put Innovators at Risk*, Princeton University Press, Princeton NJ.
Bezemer, D.J. (2014) 'Schumpeter might be right again: the functional differentiation of credit', *Journal of Evolutionary Economics*, 24, 5, pp.935–50.
Blackstone, T. (1990) *Inside the Think Tank: Advising the Cabinet, 1971–83*, Mandarin, London.

Boldrin, M. and Levine, D.K. (2008) *Against Intellectual Monopoly*, Cambridge University Press, Cambridge.
Buchanan, J.M. and Tullock, G. (1962) *The Calculus of Consent*, University of Michigan Press, Ann Arbor.
Coccia, M. (2012) 'Political economy of R&D to support the modern competitiveness of nations and determinants of economic optimization and inertia', *Technovation*, 32, 6, pp.370–79.
Federico, P.J. (1978) 'Origins of Section 103' in Witherspoon, J.F. (ed.) *Non-obviousness – The Ultimate Condition of Patentability*, Bureau of International Affairs, Washington DC.
Gordon, R.J. (2012) *Is US Economic Growth Over?: Faltering Innovation Confronts the Six Headwinds*, NBER Economic Paper No. 18315.
Grabowski, H. (2005) 'Increasing R&D incentives for neglected diseases: lessons from the Orphan Drug Act' in Maskus, K. E. and Reichman, J. (eds) *International Public Goods and Transfer of Technology under a Globalized Intellectual Property Regime*, Cambridge University Press, Cambridge, pp.457–80.
Heggen, A. (1975) *Erfindungschutz und Industria1isierung in Preussen, 1793–1877*, Vandenhoeck und Ruprecht, Göttingen.
Irish Parliament (1721) Act (29 Geo 2 c.16).
Kash, D.E. (1989) *Perpetual Innovation*, Basic Books, New York.
Keynes, J.M. (1936) *The General Theory of Employment, Interest and Money*, Macmillan, London.
Kingston, W. (ed.) (1987) *Direct Protection of Innovation*, Kluwer Academic Publishers for the European Commission, Dordrecht.
Kingston, W. (1994) 'Compulsory licensing with capital payments as an alternative to monopoly grants for intellectual property', *Research Policy*, 23, 5, pp.1275–89.
Kingston, W. (2000) 'Antibiotics, invention and innovation', *Research Policy*, 29, pp.679–710.
Kingston, W. (2006) 'Trade mark registration is not a right', *Journal of Macromarketing*, 26, 1, pp.17–28.
Kingston, W. (2010) *Beyond Intellectual Property: Matching Information Protection to Innovation*, Edward Elgar, Cheltenham.
Kingston, W. (2014) 'Schumpeter and the end of Western capitalism', *Journal of Evolutionary Economics*, 24, 3, pp.449–77.
Lazonick, W. (2009) *Sustainable Prosperity in the New Economy: Business Organization and High-tech Employment in the United States*, WE Upjohn Institute for Employment Research, Kalamazoo MI.
Lessig, L. (2004) *Free Culture*, Penguin Books, New York.
McCloskey, D. (2010) *Bourgeois Dignity: Why Economics Can't Explain the Modem World*, University of Chicago Press, Chicago, IL.
Merges, R. (1992) 'Uncertainty and the standard of patentability', *High Technology Law Review*, 7.
Mill, J.S. (1862) *Principles of Political Economy*, 5th edn, Parker, Son, and Bourn, London.
Mowery, D.C., Nelson, R.R., Sampat, B.N. and Ziedonis, A.A. (2001) 'The growth of patenting and licensing by US universities: an assessment of the effects of the Bayh-Dole act of 1980', *Research Policy*, 30, 1, pp.99–119.
Norway, N.S. (1954) *Slide Rule: The Autobiography of an Engineer*, Heinemann, London.
Nowotny, E. (2004) 'Evolution of structures of European policy', *Journal of Evolutionary Economics*, 14, 2, pp.211–15.
Philippon, T. and Reschef, A. (2009) *Wages and Human Capital in the US Financial Industry: 1909–2006*, National Bureau of Economic Research Working Paper No. 14644.
Piketty, T. (2014) *Capital in the Twenty-first Century*, translated by A. Goldhammer, The Belknap Press of Harvard University Press, Cambridge MA.
Ripert, G. (1946) *Aspects Juridique du Capitalisme Moderne*, Laval, Paris.
Schapiro, J. (2012) Letter to *Financial Times* (US edition), 15 May.
Schumpeter, J.A. (1942) [1997] *Capitalism, Socialism and Democracy*, Allen and Unwin, London.
Sell, S. (2003) *Private Power, Public Law: The Globalization of Intellectual Property*, Cambridge University Press, Cambridge.

Sheppard, D.K. (2006) *The Growth and Role of UK Financial Institutions, 1880–1962*, Routledge, London.
Sichelman, T. (2010) 'Commercializing patents', *Stanford Law Review*, 62, 2, p.341.
Skidelsky, R. (1995) *The World After Communism*, Macmillan, London, p.xiii.
Weiss, L.M. (2014) *America Inc.?: Innovation and Enterprise in the National Security State*, Cornell University Press, Ithaca and London.