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Is intellectual property important for future manufacturing activities?

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Is intellectual property important for future manufacturing activities?

By

Professor Bronwyn H. Hall
University of California

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Executive summary

The use of formal intellectual property rights protection mechanisms (IPRs) by firms has increased in importance globally during the past 40 or so years, due to the rise of the knowledge economy. This report looks at the use of these instruments in the specific area of UK manufacturing. It contains an overview of the current global trends in manufacturing, intangible investment and IP use. It then looks at the current use and importance of IPRs by UK manufacturing firms, which industries rely on it, and which types they rely on, and the strengths and weaknesses of the metrics that measure IP use. Final sections provide a brief discussion of the patent box and a longer discussion of where things might be going in the future.

The report documents the following trends in manufacturing:

- The manufacturing sector is a shrinking share of the economy in most developed countries.
- Nevertheless, manufacturing remains important, because many related service activities remain in the country even when actual production is outsourced.
- R&D-GDP ratios are stagnant in the West and growing in the East.
- Intangible assets are growing relative to tangible assets everywhere.
- There is an increased use of patents worldwide, especially in electrical and digital technologies, broadly defined.
- Some products which formerly were manufactured physical products are now being sold in digital form, with no manufacturing required.
- The “internet of things” – the use of wireless communication and smart technology, even in goods that are not traditionally considered high technology – will continue to grow.
- There are new business opportunities available due to the ability to customize products more cheaply.

The implications of the previous propositions for IP in manufacturing are the following:

- The increased importance of intangible assets means increased importance in securing returns from those assets, implying more attention to IP issues on the part of firms.
- IP protection of intangible assets becomes more, not less, important when innovation involves interacting with other firms. This includes the open innovation paradigm.
- The presence of IP-protected standards for such technologies as the wireless communication of data implies an increased need for manufacturers of all kinds to license in technology and standards-essential patents.
- The importance of standards-essential patenting extends beyond the wireless and electronic equipment sector, and is likely to affect almost all manufacturing industries.
- The rise of 3D printing raises a whole new set of IP issues involving consumer and other reproduction of protected products.
- Copyright per se may become less important in the manufacturing sector as the production of copyright-protected goods moves out of the sector.
- Increased attention to IP has led in some cases to more awareness of problems in its implementation and therefore legislative changes in some countries.
- The new European unitary patent and unified patent court may complicate rather than simplify firm patenting strategies.

1. Introduction

The use of formal intellectual property rights protection mechanisms (IPRs) by firms has increased in importance globally during the past 40 or so years, due to the rise of the knowledge economy. This report looks at the use of these instruments in the specific area of UK manufacturing. It contains an overview of the current global trends in manufacturing, intangible investment and IP use. It then looks at the current use and importance of IPRs by UK manufacturing firms, which industries rely on it, and which types they rely on, and the strengths and weaknesses of the metrics that measure IP use. Final sections provide a brief discussion of the patent box and a longer discussion of where things might be going in the future. To summarize the argument of the report, the manufacturing sector IP landscape has the following features:

- The manufacturing sector is a shrinking share of the economy in most developed countries.
- Nevertheless, manufacturing remains important, because many related service activities remain in the country even when actual production is outsourced.
- R&D-GDP ratios are stagnant in the West and growing in the East.
- Intangible assets are growing relative to tangible assets everywhere.
- There is an increased use of patents worldwide, especially in electrical and digital technologies, broadly defined.
- Some products which formerly were manufactured physical products are now being sold in digital form, with no manufacturing required.
- The “internet of things” – the use of wireless communication and smart technology, even in goods that are not traditionally considered high technology – will continue to grow.
- There are new business opportunities available due to the ability to customize products more cheaply.

The implications of the previous propositions for IP in manufacturing are the following:

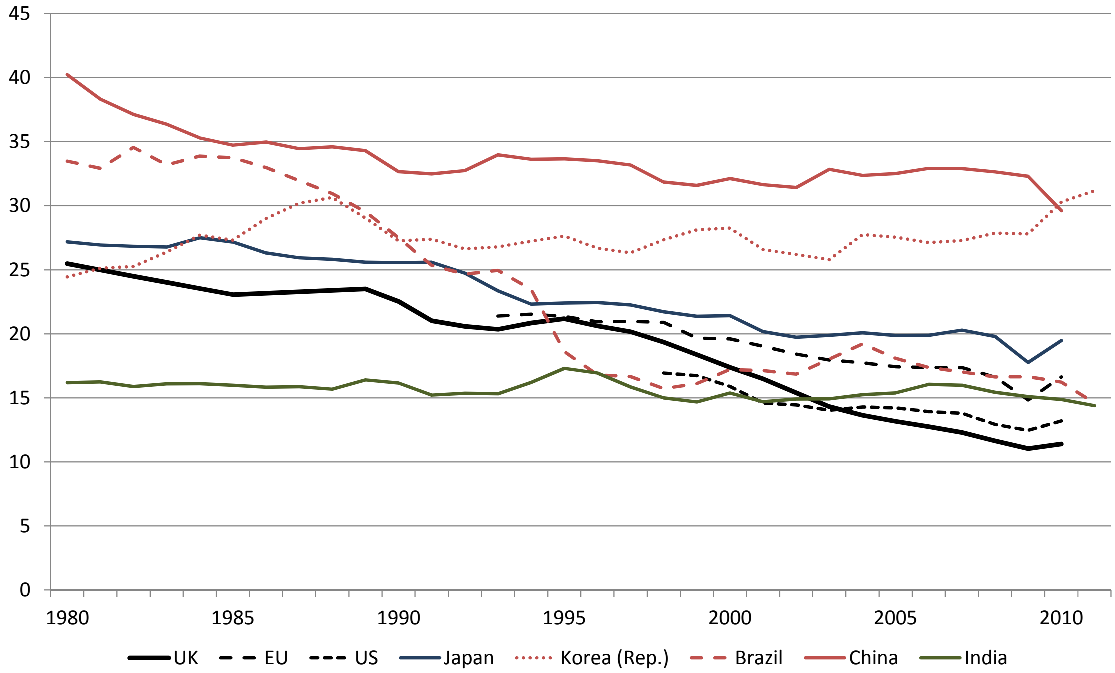
- The increased importance of intangible assets means increased importance in securing returns from them, implying more attention to IP issues on the part of firms.
- IP protection of intangible assets becomes more important when innovation involves interacting with other firms.
- The presence of IP-protected standards for wireless communication of data implies an increased need for manufacturers of all kinds to license in technology and standards-essential patents.
- The importance of standards-essential patenting extends beyond the wireless and electronic equipment sector, and is likely to affect almost all manufacturing industries.
- Copyright *per se* may become less important in the manufacturing sector as the production of copyright-protected goods moves out of the sector.

This report begins with a brief overview of the international trends in manufacturing and intangibles investment together with a somewhat more detailed review of IP use globally. This is followed by an examination of current IP use by UK manufacturing firms and a look at the patent box policy. The report concludes with some speculation about future trends in manufacturing that may impact IP and trends in IP use that may impact manufacturing. There are two appendices to the report: 1) a detailed look at the determinants of IP use in UK manufacturing based on several editions of the UK Community Innovation Survey; and 2) a brief overview of the principal formal IP protection mechanisms available in the UK.

2. Trends in manufacturing and investment

Although other reports in this series will presumably contain more detail about the current trends in UK manufacturing, it is useful to present some information here as background to the main topic. First, Figure 1 documents that the share of manufacturing value added in UK GDP has fallen faster over the past 30 years than in other countries, from 25 per cent to slightly over 10 per cent. The share in other developed sectors (the EU, US, and Japan) has also fallen, but not by quite as much, and that in India, China, and Korea has stayed roughly constant. In fact, according to the detailed data reported by the World Bank, there is no country in which the manufacturing share has risen, underlying the increased importance of the service sector in the global economy.[1]

Figure 1: Manufacturing value added share of GDP



Source: World Bank Database. Manufacturing refers to industries belonging to ISIC (rev. 3) divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs.

2.1 Intangible investment in manufacturing

As manufacturing has declined in importance in developed economies, the composition of investment (tangibles vs. intangibles) in these economies has also shifted. Corrado et al. (2012) have compiled a set of harmonized numbers for intangible and intangible investment in the United States and the EU15 region, drawn from the COINVEST and INNODRIVE projects in Europe and Conference Board work in the United States. Their definition of intangible investment includes computerized information (software and databases), innovative property (mineral exploration, R&D, entertainment and artistic

[1] One cautionary note is needed here. Because the measures in Figure 1 are based on value added, changes in outsourcing will affect them. In particular, when activities such as personnel management, janitorial services, computer services, etc. are outsourced to service firms rather than included in the manufacturing firm itself, the service sector grows at the expense of the manufacturing sector. This may be a factor in some developed countries.

originals, new products/systems in financial services, design and other new products/systems), brand equity (advertising and market research), and firm-specific resources (employer-provided training and investment in organizational structure). Their figures are reproduced in Table 1, which shows that both the US and the UK and Ireland have spent roughly the same amounts on tangible and intangible investments during the 1995-2009 period, whereas the rest of Europe has spent somewhat less on intangibles than on tangibles and the US has spent more. However in all countries, the trend is clearly towards more investment in intangibles, even during the 2008-2009 downturn in some cases.

Table 1: Tangible vs. Intangible GDP shares

	Average 1995-2009		**% Change 1995-2007**		**% Change 2007-2009**	
Region	**Tangibles**	**Intangibles**	**Tangibles**	**Intangibles**	**Tangibles**	**Intangibles**
US	9.0	10.6	-9.0	33.0	-11.1	-0.1
EU15	10.6	6.6	0.7	20.8	-12.6	-5.1
Scandinavia*	11.2	7.9	1.6	29.1	-9.2	2.3
Anglo-saxon*	9.4	8.7	-15.5	20.1	-31.0	1.1
Continental*	9.9	6.9	-0.9	19.5	-9.0	3.2
Mediterranean*	12.5	4.2	12.2	20.1	-13.6	-3.1

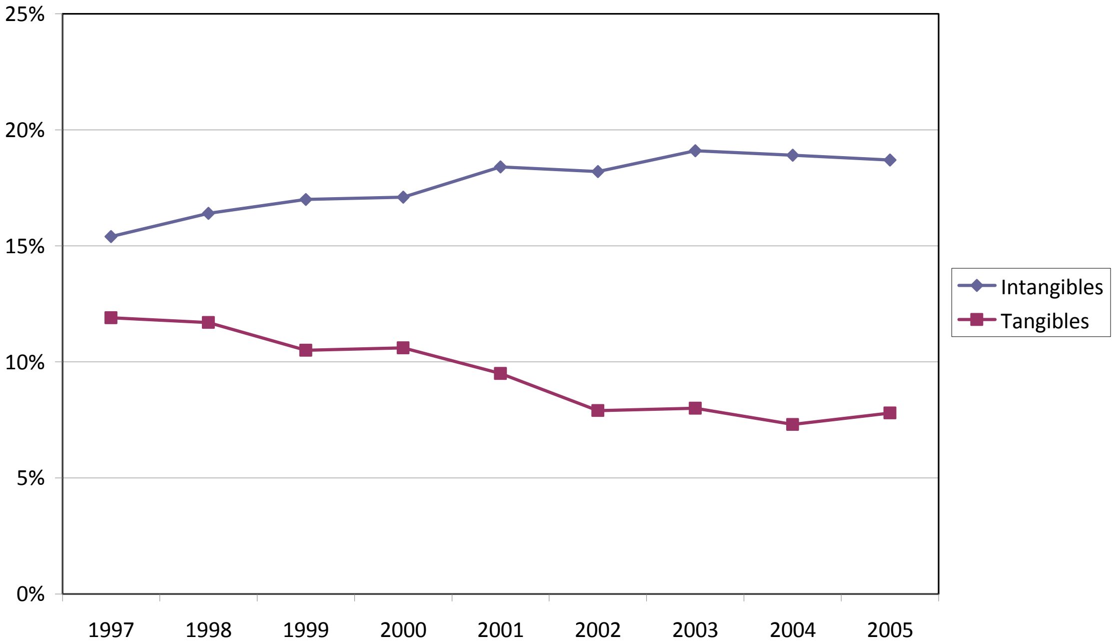
Scandinavia = Denmark, Finland, Sweden; Anglo-saxon = UK, Ireland; Continental = Austria, Belgium, France, Germany, Luxembourg, Netherlands; Mediterranean = Greece, Italy, Portugal, Spain

Source: Corrado et al. (2012), Figures 5-7

The numbers in Corrado et al. (2012) are for the private sector of the economy as a whole (NACE Rev. 1 sectors A-K excluding real estate, plus sector O, which includes sanitation services, membership organizations, and recreational activities). They were not available for the manufacturing sector by itself in a harmonized way.

Figure 2, drawn from Haskel et al. (2009), shows the investment trends for UK manufacturing alone. As a share in value added, tangible investment has fallen from 12 per cent of value added to about 8 per cent over a recent nine-year period, whereas intangible investment has risen from 15 per cent to 19 per cent, and is now twice as large as tangible investment. Later in the report we discuss the composition of this investment in more detail and the implications for intellectual property protection.

Figure 2: Investment as a share of UK manufacturing value added



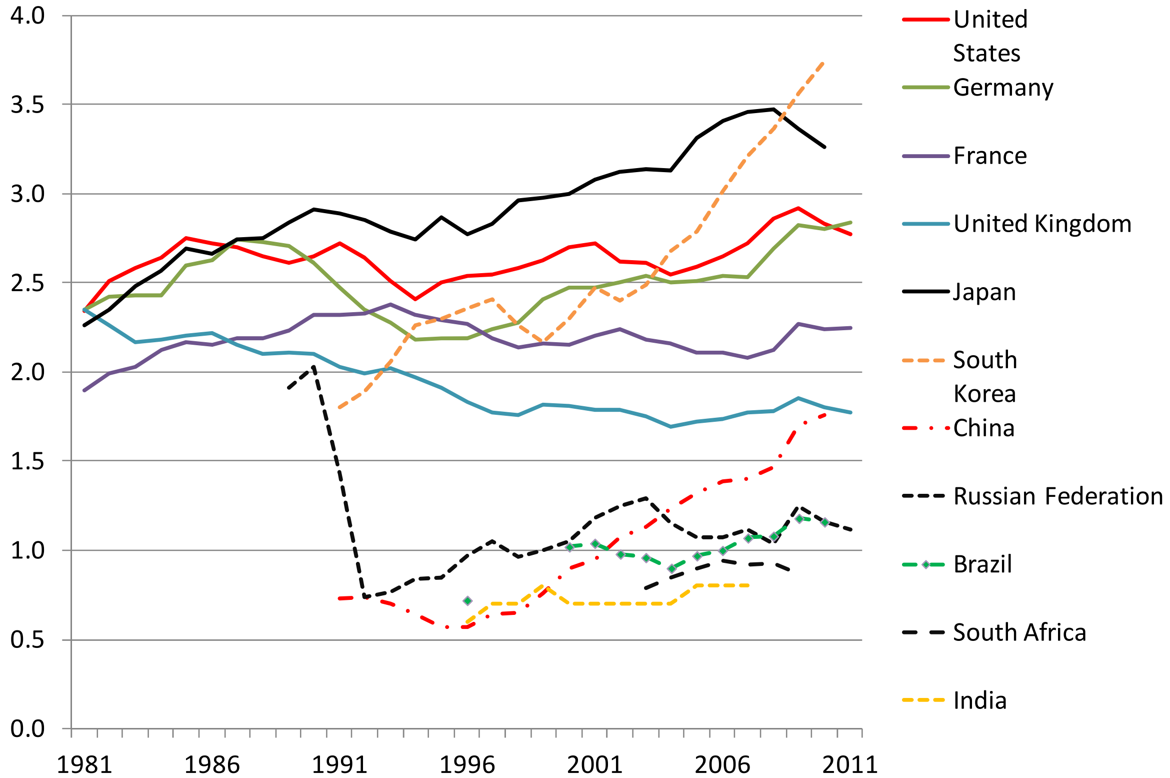
Source: Haskel et al. (2009)

2.2 Trends in R&D investment

This section of the report looks at the worldwide trends in an important form of intangible investment, R&D. As the report shows later, this investment is by far the most important intangible investment in the UK manufacturing sector. Wherever possible, trends in the manufacturing sector are examined specifically, but in some cases the appropriate data are missing, especially for R&D by industry in developing countries.

Figure 3 shows the overall R&D to GDP ratio (R&D intensity) for the top 5 developed countries and the largest developing countries. R&D intensity is the measure commonly used by policy makers as an indicator of S&T activity and is therefore the most widely available measure. It covers the entire economy rather than the manufacturing sector, and is therefore affected by such things as the share of defence spending in the government budget, since defence tends to be quite R&D-intensive. The figure shows that the only developed country with a significant increase in this ratio during the past 30 years is Japan, and that the R&D intensity in the UK has declined from about 2.3 per cent to 1.8 per cent during the period. Data for the BRICS and South Korea show contrasting patterns: in South Korea and China, R&D intensity has grown rapidly since the mid-1990s, whereas in Russia, Brazil, South Africa, and India, what growth there is somewhat slower and all four countries have an R&D intensity that hovers around one per cent. To a great extent, the patterns in this figure reflect the importance of ICT in the manufacturing sectors of the different economies, with the Asian countries clearly leading the others, followed to some extent by the US.

Figure 3: R&D/GDP trends for the top R&D-doing countries and the BRICs

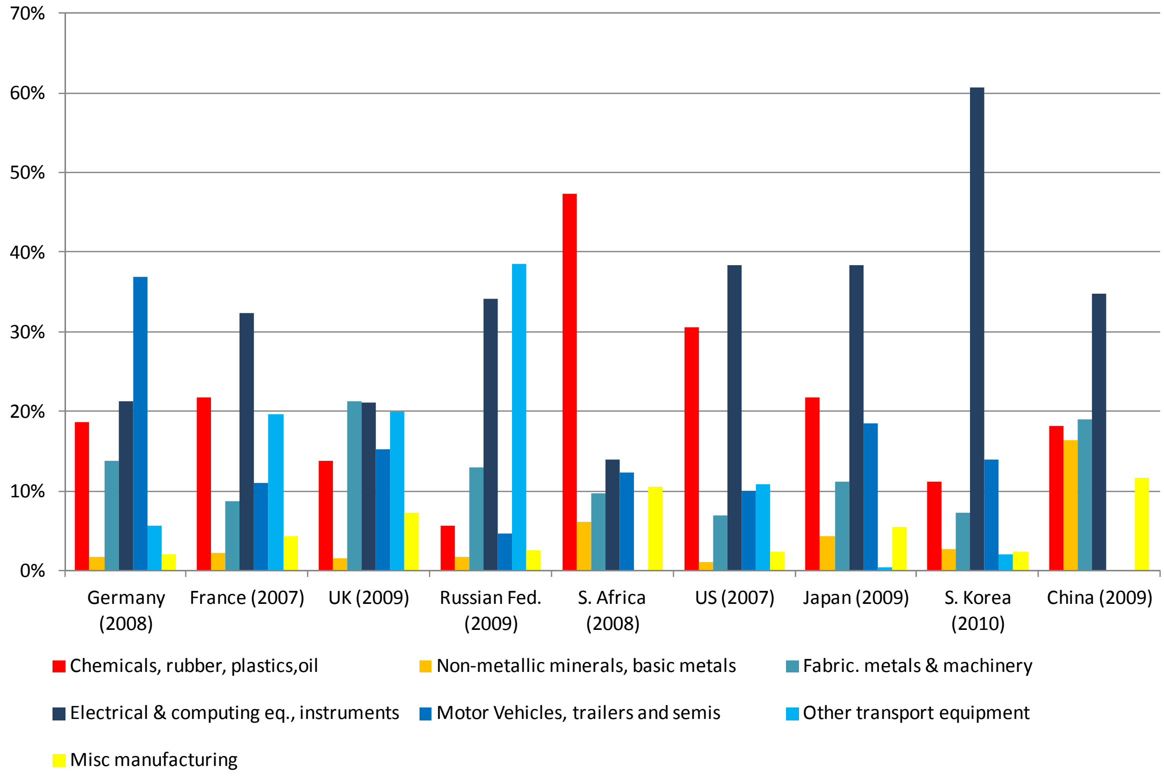


Source: OECD Main Science and Technology Indicators (2011/1); NSF Science & Engineering Indicators 2012; RICYT website; World Bank databank.

Figure 4 shows the distribution of industrial R&D across manufacturing sectors for a set of OECD economies plus Russia, South Africa, and China.[2] This figure reveals considerable differences in specialization across countries. The economies with the highest shares in the chemical sector are the US and South Africa, whereas Germany's largest share of R&D is in motor vehicles and Russia's in other transport equipment (including aircraft). South Africa and China have significant shares of R&D in metals, non-metallic minerals, and miscellaneous manufacturing, suggesting a greater importance of raw materials and medium to low technology manufacturing in those economies. Most importantly, although all the countries in the figure have R&D in the electrical and computing equipment sector including information technology, the leading countries are the US, Japan, South Korea, and China. The importance of this sector is what underpins the aggregate growth figures and also the growth in patenting described later.

[2] Figures for the industrial composition of R&D in India and Brazil do not seem to be available in the OECD, UNESCO, or World Bank databanks.

Figure 4: Industrial composition of R&D spending – latest year available



Source: OECD R&D statistics.

3. Worldwide trends in intellectual property use

This section of the report looks at the worldwide trends in IP use, in order to provide a context for examining the landscape faced by UK firms. I focus on the use of formal IP protection mechanisms, because there is little data on the use of informal mechanisms outside the various innovation surveys.[3] In comparison to R&D and other intangible investment, formal IP data tends to be more uniformly collected across developed and developing countries, thanks to the efforts of the World Intellectual Property Organization (WIPO) and the worldwide Patent Cooperation Treaty (PCT) system.

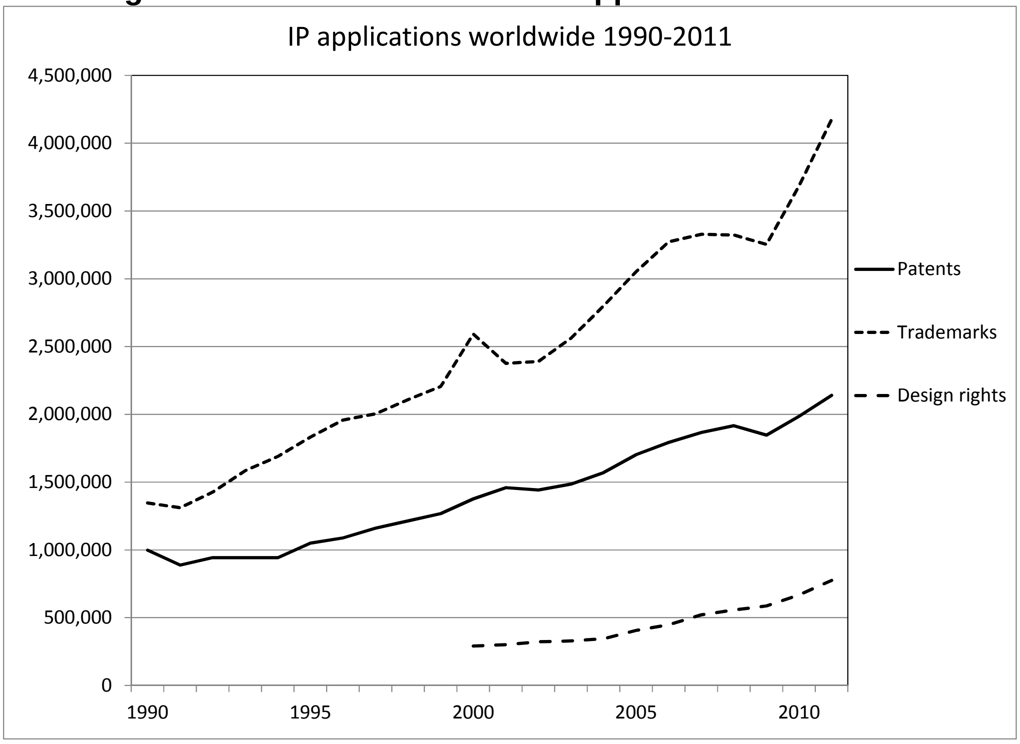
3.1 Growth in IP use

There is a worldwide growth of the use of formal IP protection methods, including patents, trademarks, and industrial design rights. This has lead to considerable duplication of effort at the various IP offices because firms tend to seek protection in most of the countries to which they market. As a consequence, there have also been a number of efforts to harmonize some of the search and examination process. For example, the PCT route for patent application allows a patent application to obtain a single search report although it still must be examined in every office for which the applicant seeks a grant. The Hague System for the International Registration of Industrial Designs provides a similar service for design rights. For trademarks, 85 countries participate in the Madrid System for international trademark registration. But in all cases, the actual issue of a patent, design right, or trademark certification rests with national offices.[4]

Figures 5 and 6 illustrate the problem faced by intellectual property offices and firms competing in a global market: Figure 5 shows the aggregate growth of patent and trademark applications worldwide and Figure 6 shows the number of patent applications received by the major offices in each year, including applications via the PCT (Patent Cooperation Treaty) route. Worldwide applications have increased from about one million in 1990 to over two million in 2011. The major reasons for this increase are 1) increased patenting in the high technology sectors, especially in the United States (where software is patentable), and some Asian countries, notably Korea and China; and 2) more recently, globalization in patenting, with patents on the same invention being taken out in more countries.

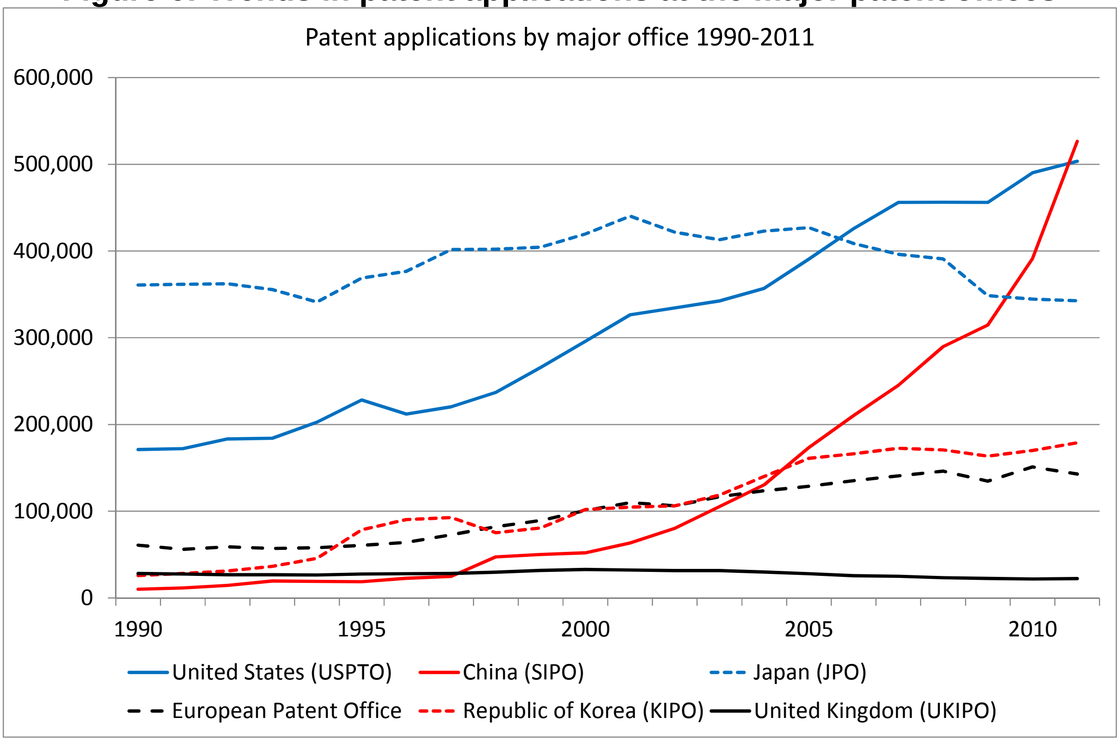
[3] For detailed descriptions of these IP mechanisms as they are legally defined in the UK, see Appendix B.
[4] This is an oversimplification. At the present time in Europe, the EPO can search, examine, and issue a notice of allowance for a patent, but it will need to be validated in each of the designated states for which the firm desires patent protection at the national office of that state.

Figure 5: Patent and trademark applications 1995-2011



Source: WIPO Patent Statistics 2012

Figure 6: Trends in patent applications at the major patent offices



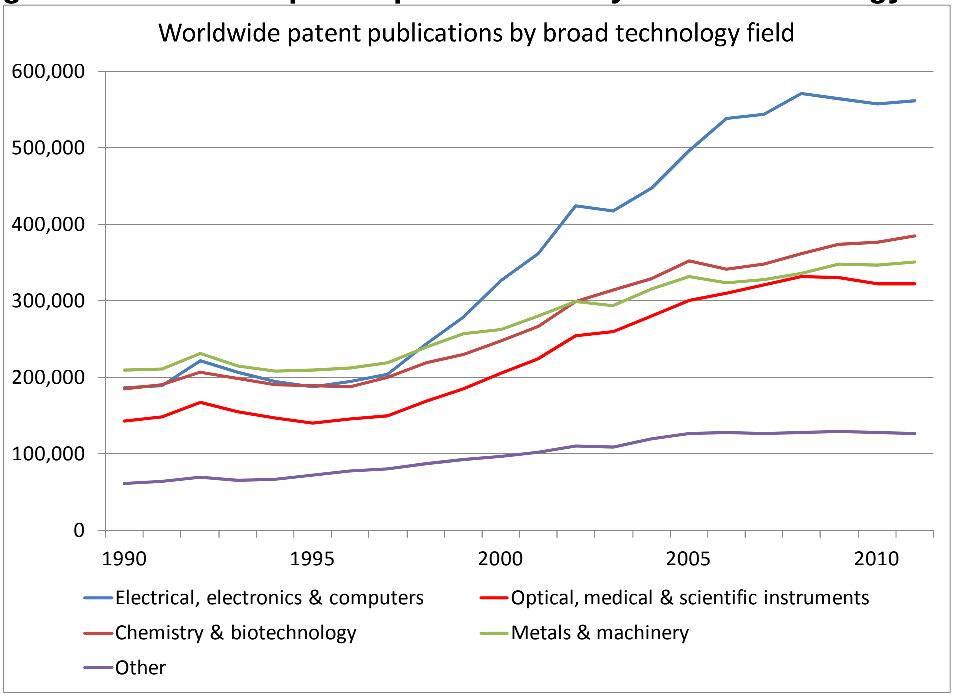
Source: WIPO Patent Statistics 2012

Looking at Figure 6, the only office that shows a decline in recent years is Japan.[5] All the other major offices show growth, at average annual rates between 2000 and 2011 of 91

[5]Note that because UK patenting at the EPO has increased, patent applications at the UK office do not show much of an increase and are probably not a good indicator.

per cent at SIPO, 7.5 per cent at KIPO, 7 per cent at the USPTO, and 4 per cent at the EPO. These growth rates reflect to some extent the relative growth of the relevant economies, but they also reflect the increasing importance of patenting in high tech sectors, specifically information and computer technology, as confirmed by Figure 7, which shows the worldwide publication totals for patents in five broad technology sectors (as defined by WIPO). Since 2000, the average annual growth of patenting in the electric & computing technologies (including digital communications) has been 7.2 per cent, whereas in instruments and chemicals it was about 5 per cent. In metals, machinery, and other technologies, growth rates were closer to 3 per cent per annum. If we could compute these statistics by industry (the firms that hold the patents) rather than broad technology field (by patent classifications), the difference between electric technologies and the others would probably be even greater, as shown by Hall (2005) for US data during a slightly earlier period.

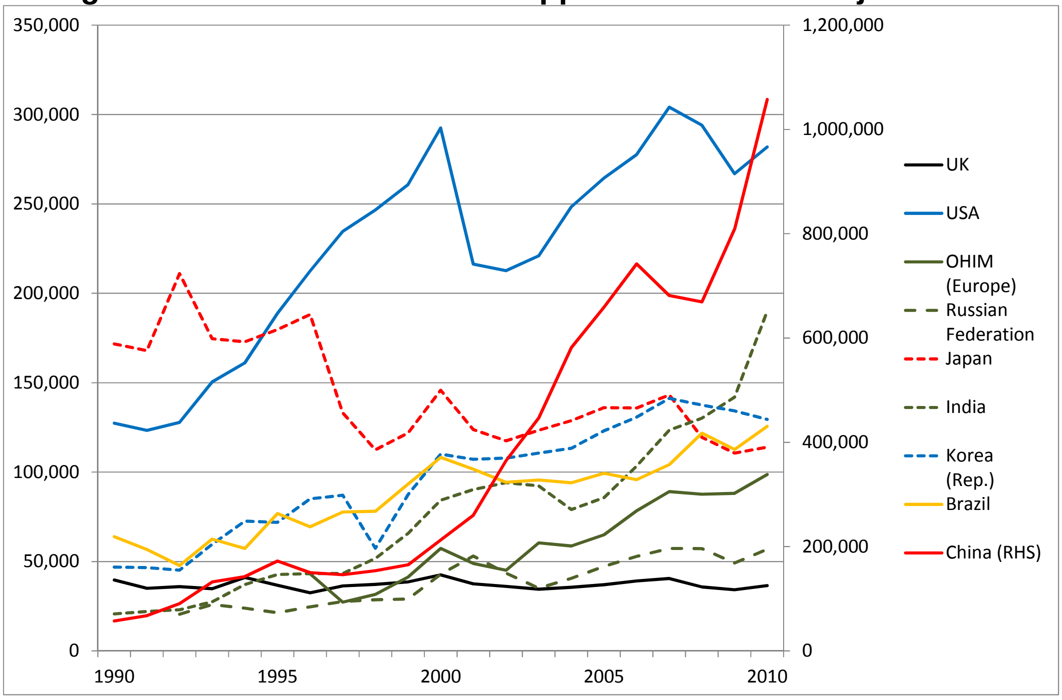
Figure 7: Worldwide patent publications by broad technology field



Source: WIPO Patent Statistics 2012

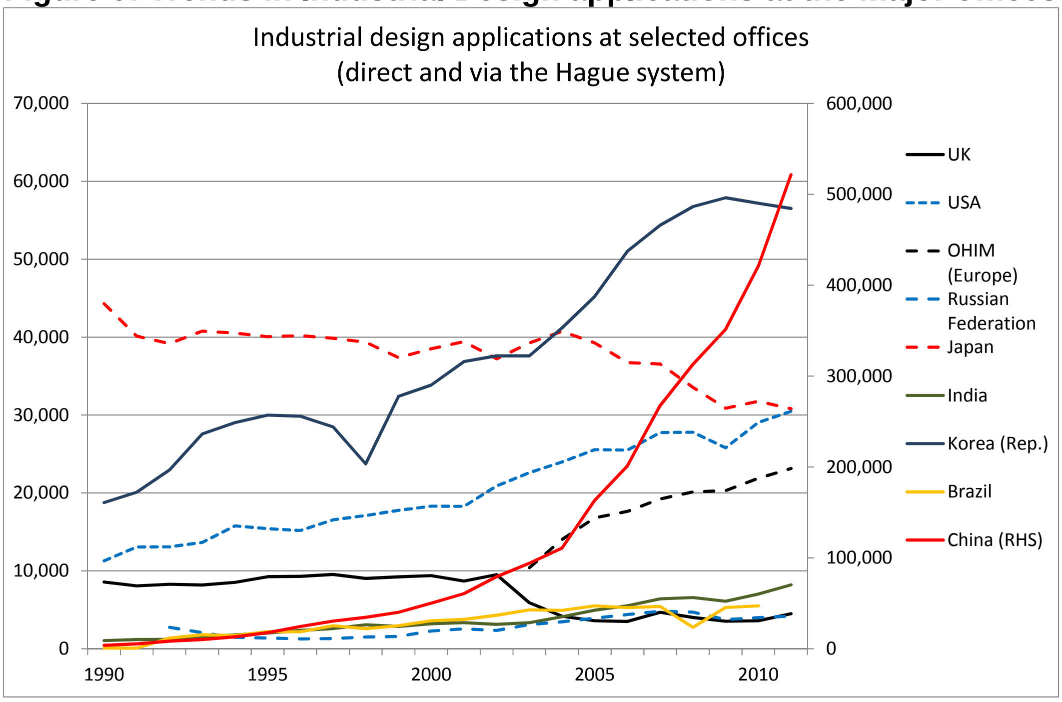
Figures 8 and 9 show the trends in trademark and design right applications at some major offices. The main thing to note is the high level and high growth rate of the applications at SIPO, the Chinese Intellectual Property Office, which reflect growth in applications both by residents and by non-residents. In the case of design rights, there are now approximately ten times as many applications per year in China as compared to the next highest number, in the Republic of Korea. To some extent this reflects a shift in strategy announced in China in 2006 that emphasized “indigenous innovation” and the acquisition of IPRs by Chinese firms. During this period SIPO was consolidated from the individual regional patent offices and a number of policy instruments were adopted by local governments to subsidize and encourage patenting and the acquisition of other IP rights by Chinese firms (Sha, 2011).

Figure 8: Trends in Trademark applications at the major offices



Source: WIPO IP Statistics 2012

Figure 9: Trends in Industrial Design applications at the major offices



Source: WIPO IP Statistics 2012

Table 2 gives some detail on the source of the recent increase in IP filings in China, for patents, trademarks, design rights, and utility models, which are a form of petty patent. In general, the growth from resident filings is much greater than the growth in non-resident filings, reflecting the shift in strategy. The shift has especially affected patenting. Eberhardt et al. (2011) show that in the case of patenting, growth through 2006 is accounted for by a few large Chinese firms in the ICT sector. However, it is doubtful that these same few firms can account for the growth since then in all IP areas.

Table 2: IP filings in China (total via all routes)

		2004	2011	Growth rate
Patents	Resident	64,598	415,829	544%
	Non-resident	65,786	110,583	68%
Trademarks	Resident	527,591	1,273,827	141%
	Non-resident	54,214	114,572	111%
Design rights	Resident	101,572	507,538	400%
	Non-resident	9,270	13,930	50%
Utility models	Resident	111,578	581,303	421%
	Non-resident	1,247	4,164	234%

Source: WIPO Statistics Database

Looking at the trends in UK trade marking, we see that total applications to the UKIPO have remained stagnant during the past 20 years, although applications to the European Office of Harmonization in the Internal Market (OHIM) have doubled, and doubtless a fairly large share of these are from the UK. A similar thing happened to design right applications: with the introduction of the Hague system, applications to the UKIPO fell in half, but there has been a corresponding increase in the applications to OHIM.

Figure 10 shows the trends in trademark applications. This figure has been constructed by collapsing the 34 goods classes and 11 service classes into 10 goods classes and 3 service classes. Among the three largest classes, two are services and these two categories are also the fastest growing, at 14 per cent per year (business) and 12 per cent per year (personal). Among goods marks, food, apparel, and instruments are the largest.

Figure 10: Worldwide trademark applications by class

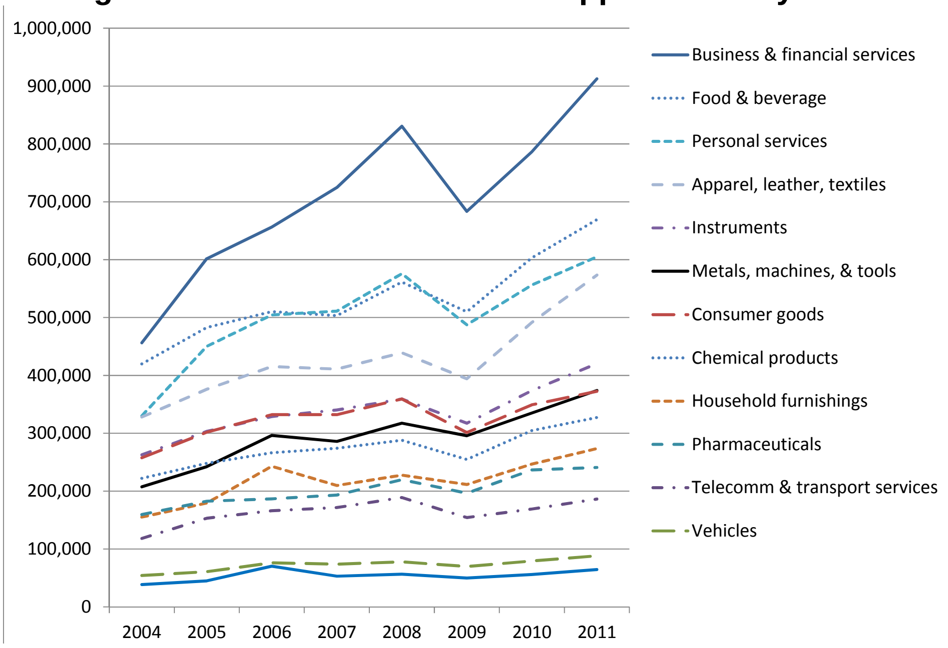


Table 3 shows the distribution of trademark applications by UK residents, as compared to the worldwide distribution. UK applicants are over represented in all the service sectors (business, personal, and telecommunications and transport), as well as in instruments and consumer goods. Instruments include a wide range of medical and surgical instruments, as well as electrical and electronic equipment, so it is an innovation and R&D-intensive area. Consumer goods consist of jewellery, clocks and watches, games and sporting equipment, musical instruments, firearms, and explosives, also somewhat innovation-intensive areas. The fact that pharmaceutical trade marking is relative low may seem surprising, but this doubtless reflects that fact there is very active trade marking in this area in developing countries, most of which may not be for new products, but only for the introduction of a product into the country.

Table 3: Trademark applications in 2011 by class

Broad trademark class	*World*	*UK*
Business & financial services	17.8%	20.9%
Personal services	11.8%	13.7%
Instruments	8.2%	11.7%
Consumer goods	7.3%	10.7%
Apparel, leather, textiles	11.2%	9.7%
Food & beverage	13.1%	8.0%
Metals, machines, & tools	7.3%	5.1%
Household furnishings	5.4%	5.1%
Chemical products	6.4%	5.1%
Telecomm & transport services	3.6%	5.0%
Pharmaceuticals	4.7%	2.9%
Vehicles	1.7%	1.2%
Misc rubber, plastic, strong packing materials	1.3%	0.9%
Other	0.1%	0.0%

4. IP and intangible assets in UK manufacturing

In developed countries including the UK, manufacturing has become a relatively small share of the overall economy, not necessarily because manufacturing firms themselves have shrunk, but because they tend to outsource much of their actual manufacturing to the less developed world, leaving service sector aspects of their activities in headquarters countries. The parts of manufacturing that are likely to remain within developed countries are often closer to the technological frontier. They may require closer association between R&D laboratories and the manufacturing process, or they may find being close to the consumer of their products to be an advantage. Related to these trends has been a greater need for technology collaboration between firms, as described by the well-known “open innovation” model.[6]

How are intellectual property protection mechanisms used in manufacturing and how important are they to the firms that use them? In this section of the report I review several sources of evidence on these questions. The first is a recent report by Goodridge, Haskel, and Wallis (2012) that presented estimates of the value of intangible assets in various UK sectors and highlighted the importance of manufacturing in this respect. The second source are the various Community Innovation Surveys conducted in the UK, which asked questions about firm’s use or importance rating of the various forms of IP protection. Third, I summarize what we know about the contribution of IP-protected assets to firm performance, measured as profits, growth, or market value.

According to the Goodridge *et al.* report, although manufacturing accounts for only 17 per cent of hours worked in the UK during the 2000s, it contributed 47 per cent of the growth in market sector value added (VA) and total factor productivity (TFP). The share of investment in intangible assets by the manufacturing sector was 23.4 per cent in 2007. Using conventional growth accounting methodology and assuming that the main contribution to TFP growth comes from intangibles, these numbers suggest a contribution from intangible investment that is greater than its share. The breakdown of this investment is shown in Table 4.

[6] See Chesbrough (2000) and Arora et al. (2004) for more information on open innovation and the growth of technology markets and alliances.

Table 4: Intangible investment in the manufacturing sector (2007)

Type	*Investment (billions of pounds)*	*Share (%)*
Software (purchased & own account)	2.9	9.8
Scientific R&D	11.8	40.0
Arch. & eng. design (purchased & own account)	3.8	12.9
Artistic originals	0.0	0.0
Mineral exploration	0.0	0.0
Financial product innovation	0.0	0.0
Non-scientific R&D	0.0	0.0
Advertising & market research	2.3	7.8
Training	3.8	12.9
Organizational capital (purchased & own account)	4.9	16.6
Total	**29.5**	

Source: Goodridge et al. (2012), Table 4.

Although it is difficult to be precise, the table gives us some idea of the particular forms of IP protection that might be important in manufacturing: *patents* to protect the output of scientific R&D, *design rights* for the output of design activities, perhaps combinations of *copyright, patenting* and *trade secrecy* for software, and *trademarks* for the brand investment like advertising. Of course, things are not as clear-cut as this: in some cases combinations of these rights will be used. For example, we might observe trademarks being used to protect some of the output of design efforts, or copyright used to protect training materials. We also expect that trademarks will be associated with the launch of new products that are the outgrowth of R&D investments.

Given the importance of intangible assets to UK manufacturing firms reported above, I now turn to evidence on the means that firms use to protect these assets from exploitation by competitors and others. These means include formal IP rights, but they also include informal methods such as secrecy, lead time, product complexity, and complementary assets.

4.1 Current use of IP by UK firms

Information on firm use of intellectual property protection mechanisms comes from European Community Innovation Surveys for the UK. These surveys, which have been conducted every 2 or 3 years since 1996, provide data on the importance attached to various modes of IP protection by UK firms, and the extent to which they use these modes. Appendix A in this report gives some details on the results from the 2005, 2007, 2009, and 2011 surveys, which cover the nine-year period 2002-2010.

One problem with the information we have from the innovation surveys is that the answers are very qualitative and do not tell us exactly how intensively the firms are using these methods, or even whether they are actually using them. In particular, the surveys prior to the CIS6 (2009, covering 2006-2008) the form of the question was the following: *Please indicate the importance to your enterprise of each of the following methods to protect innovations: not used, low, medium, high.*

Beginning with the CIS6, the question changed to a yes/no question about actual use of patents, registered design rights, trademarks, and copyrights. Besides making it difficult to identify trends, neither of these question completely captures the intensity with which the methods are actually used. In addition, the importance rating is presumably related to a stock concept of IP rights, whereas the question about use refers to a flow (the past three years).Nevertheless, some information is better than none, and below I summarize what these data have to say.

The numbers in Table A1 in the appendix suggest that patents, copyright, and trademarks are used by roughly the same number of manufacturing firms, whereas registered designs are used by far fewer firms. However, no IP right is used by more than 10 per cent of the firms. Figures A1 and A2 show that the importance and use of IP increases with firm size, with the possibly exception of copyright, which is used as much by small firms as by medium-sized firms. The bottom panel of Table A1, which shows the employment size-weighted shares of firms using different types of IP protection, does show higher shares. The share of manufacturing employees in firms that rate IP of medium to high importance rises to about half in the 2004-2006 period. But when the question is changed to use of IP during the past three years, the shares fall to one quarter or less, which may reflect to some extent a distinction between the stock and flow of IP use along with the fact that the majority of the firms are quite small.

As expected, Table A2 shows considerable variation across industry. Within manufacturing, the chemical, machinery (including electrical, medical, and optical) equipment sectors use all forms of protection more intensively than the other sectors. However, for any given mode of IP protection, there are a significant number of firms in all sectors that either regard it as important or actually use it.

The most noteworthy feature of the data described in the appendix is that it shows very clearly that firms have an idiosyncratic "taste" for IP protection. After controlling for their size, age, industry, region, R&D, export status, cooperation with other entities, and whether they have an innovation during the relevant period, the appendix shows that there remains substantial correlation across firms in the use of the four different formal IP protection methods. It is not immediately clear what causes this effect, although it is possible that once a firm chooses to use legal advice on its IP, there is a tendency for its legal advisors to look at the possibility of all types of protection. It is also possible that firms vary with respect to the extent to which they introduce IP-protectable innovations in any given three year period, but that when they have them, they use multiple means to protect them.

4.2 IP and performance

Many researchers have explored the relationship between IP ownership and firm performance, using a variety of measures of performance including employment growth, profits or productivity, and stock market value. The central problem in interpreting the results of these explorations is that it is difficult to distinguish the value of the IP right from the value of the underlying asset for which the IP provides some protection. That is, it is not generally possible to use this approach to answer questions such as, would the value of the particular invention, brand, etc. be lower without the IP that protects it. Nevertheless, the results are still of some interest.[7]

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[7] For a fuller discussion of this issue and the related empirical results, see Greenhalgh and Rogers (2007).

Greenhalgh and co-authors (Greenhalgh and Longland 2005; Greenhalgh and Rogers 2012) are the most comprehensive studies of the relationship between IP (patents and trademarks) and the market value and value added of UK firms, both for manufacturing and services. Generally they find a positive contemporaneous relationship between the ownership of IP and both current and future profitability. However, they also highlight the fact that the industry level patent and trademark activity may be negative for firm competitors at first, although positive in the medium term (because innovation by one firm begets innovation by another, due to Schumpeterian competition). They also emphasize the relatively rapid decay of the value of assets protected by patents and trademarks. That is, to stay profitable, the firms need to continuously renew their intangible investment.

Hall, Helmers, Rogers et al. (2013) use the CIS data through 2006 to show that owning at least one patent and/or trademark is associated with higher sales shares of products new to the firm, whereas only trademark ownership appears to be related to employment growth. There are two (non-exclusive) explanations for this finding: 1) It may reflect the fact that trademarks come rather late in the product development process and are therefore more likely to be associated with the ramping up of production; 2) Many innovations and new products are not patentable or are protected by other means, but almost all will require some form of trade marking.

A brief investigation into the relationship between IP and firm productivity using the CIS data for UK firms is shown in Appendix Table A4. This table shows that the only significant stable and positive relationship is again for trademarks, which increase total factor productivity by about 0.05-0.06. In the 2004-2006 period, firms that rate patents highly are more productive, whereas in the 2008-2010 period, firms using copyrights are more productive. It is difficult to know what to make of this, as it may simply reflect the differing ways that the slowdown following 2008 affected firms of different types. That is, the relationship to productivity may not have anything to do with the actual IP ownership, but may rather reflect the precise technology strategy with which the firm operates within a two-digit industrial sector.

The conclusion from this literature is that IP ownership is positively related to firm performance, although it is difficult to tell whether it is the value of the IP protection itself or the value of the underlying asset that it protects. A second conclusion is that trademarks appear to be a broader indicator than patent counts, and are therefore useful as a measure of innovative activity across more sectors.

5. Enforcement and legal changes

Over the past two or three decades, the use of IP as a strategic tool has increased, first in the United States, then Japan, followed by the rest of the world. As firms have learned to pay more attention to the management of their IP assets, various new strategies have developed, and the landscape faced by manufacturing firms is constantly changing. In this section of the report, some of these changes are discussed. Thus far, most of the research attention has been concentrated on patents, but inevitably some of the problems found have already and will in the future spill over to the management of other IP.

5.1 Strategic patenting

Strategic patenting was defined by Harhoff et al. (2008) in a report to the European Commission as follows:

"Strategic use of the patent system arises whenever firms leverage complementarities between patents to attain a strategic advantage over technological rivals. This is anticompetitive if the main aim and effect of strategic use of the patent system is to decrease the efficiency of rival firms' production."

Informally, strategic patenting has been identified with the building of large patent portfolios that are used for defensive purposes against rivals who may threaten a suit over infringement of one or more patents. That is, rather than patents serving their traditional purpose as incentives for innovation; they become instead bargaining chips for competition in complex technologies. The modern existence of this phenomenon was first identified in semiconductor technologies by Grindley and Teece (1997) and confirmed empirically by Hall and Ziedonis (2001).[8] Such behaviour has spread to other Information and Communication Technologies (ICT), and largely accounts for the relatively higher growth in patenting in Asian economies in recent years.

This form of strategic patenting is often associated with the presence of patent thickets, because it tends to arise in areas where a single product involves technologies covered by patents held by a large number of firms, and where many of the patents are "standards essential," that is, they cover technologies without which it would be impossible to compete in a certain market. The most obvious example is one where litigation has been highly visible, digital telecommunications and smart phone technologies. As a consequence of developments like this, it is possible that entry into certain sectors has become or will become considerably more costly due to the need to license in many technologies from other firms (Hall, Helmers, von Graevenitz et al. 2013). Another form of the strategic use of patents that has become important recently in the United States is the assertion of patents on widely used technologies by so-called "patent assertion entities" (PAEs) or "non-producing entities" (NPEs), which are known popularly as trolls. PAEs can serve a useful function by allowing the monetization and salvage of the intangible assets of bankrupt firms, but they also have potentially negative consequences for subsequent innovation that may outweigh their benefits, especially when the patents in question are of low quality, a topic to which I now turn.

[8] There also exist historical examples, such as sugar manufacture in the 19th century, although these generally involve far fewer patents.

5.2 Patent quality

Many commentators have pointed to low patent quality as the root cause behind some of the problems that have arisen in the use of patents as a competitive tool. Patent quality has different meanings to different people (see EPO ESAB 2012 for a discussion), but in this context it refers to the quality of the issued patent: does it satisfy requirements of disclosure, novelty, and non-obviousness? Are the claims clearly delineated? Can it survive opposition, re-examination, or litigation? Although patent quality is difficult to measure, a number of critiques of current patent office practice exist in the economics and legal literature, which suggests that there may indeed be some problems in this area. The reason low quality patents are problematic is that in a court system that relies on preliminary or permanent injunctions for enforcement of patents or that does not shift costs onto the loser of a suit, such patents are almost as easy to enforce as legitimate patents. Farrell and Shapiro (2008) present a model that explains why this is the case, but the intuition is simple: given the cost of going to trial even if a positive verdict is expected, an accused infringer is more likely to settle for a lesser sum, leaving the weak patent in place. There is also a free-riding effect when there are several accused infringers, since a firm that chooses to fight a patent assertion bears the full cost of invalidating the patent, but all firms benefit.[9]Because many (but by no means all) such cases concern technologies that were independently invented, the entire proceeding just produces social costs since there was unlikely to be a beneficial incentive for invention (which often took place without knowledge of the patent). The issue of patent quality and its intersection with litigation is discussed in more detail below.

5.3 Litigation

In some sectors, litigation over IP issues has been increasing worldwide, and this trend may continue. It is difficult to obtain comprehensive data on litigation, since it generally requires accessing the court records in individual jurisdictions, but we do have some information, mainly on patent litigation in the US, Germany, and the UK. The general trends are an increase in litigation that parallels the increase in patenting, and an increase in suits brought by PAEs or NPEs. The latter suits, which predominantly involve software, computing, and business method patents in the US, do appear to be associated with the previously mentioned hold-up strategy for enforcing weak or low quality patents. A number of scholars have pointed to the choice between settlement (taking a license) or pursuing a defence of non-infringement in the courts as favouring settlement even if the potential infringer views the patentee's case as weak. Reasons are the sunk costs of development already incurred and the high cost of pursuing litigation to trial, when compared to licensing fees.

In the UK so far, such cases have been relatively few, for two reasons: 1) less software/business method patenting and 2) loser pays costs, which discourages trolling for settlements. US evidence suggests that when such cases go to trial, the NPE patentee is likely to lose, so the threat of having to pay the costs of litigation is a significant deterrent. This is confirmed for the UK by Helmers and McDonagh (2012), who find few such cases and only one where the patentee prevailed. Greenhalgh et al.

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[9] Various institutions have arisen to try to solve the free-rider problem, such as PatentFreedom (McCurdy and Reohr, 2008).

(2012) report on a small scale survey of firms about the IP disputes they have been engaged in and find that about one quarter of them had been engaged in such disputes, but that most of the disputes were resolved by negotiation or an exchange of letters rather than in the courts. The number of disputes was roughly the same for patents, trademarks, and copyright, but the patent cases were more likely to end up in court. With respect to small firms, their survey suggests that the cost of enforcement is one of the factors that deter such firms from obtaining formal IP rights in the first place.

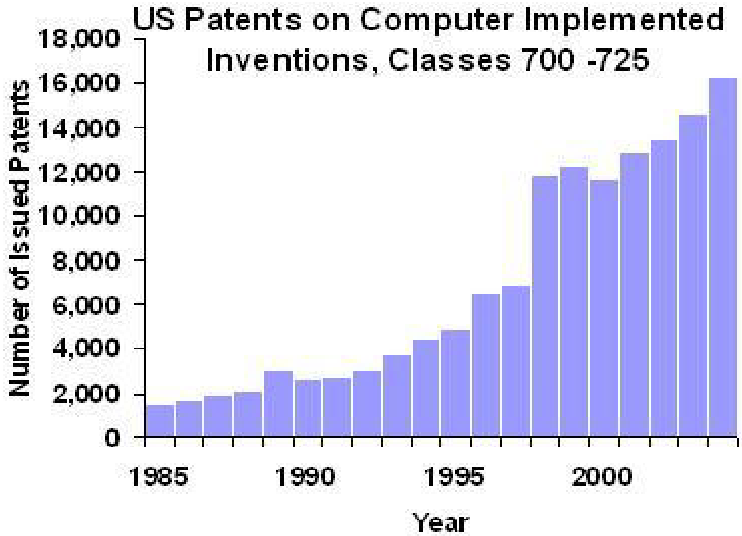
Nevertheless, there are reasons why patent licensing and litigation are of concern to UK firms now and will be even more so in the future. The central problem arises from what are called “standards-essential patents” (SEPs) along with the globalized nature of competition in the ICT sector. These are patents that cover the technological standards that are necessary for communication and interface between modern digital products. Examples are the protocol that covers recording information on DVD-Rs, involving 342 patents, and RFID technology which is covered by approximately 4000 patents worldwide, held by a large number of firms. Most standards setting organizations (SSOs) require the licensing of SEPs by their holders on fair, reasonable, and non-discriminatory (FRAND) terms. However, in the absence of specific guidelines, it is often left to individual firms to negotiate these terms ex-post, after considerable development effort has gone into using the relevant standard. A second problem in the computation of royalties is so-called “royalty-stacking” – when there are hundreds of patents involved, the use of traditional royalty rates derived from the chemicals sector can easily swamp any profit from sale of the product involved.

These facts have led to a number of well-publicized disputes, such as *Microsoft v. Motorola*, which concerns the license fees for patents tied to H.264 video and Wi-Fi standards. The relevant part of Motorola is now a unit of Google, so the suit is also an example of the use of patent licensing disputes as a weapon in the strategic interaction of large mobile computing/telephony firms. The U.S. Federal District Court in Seattle recently handed down a decision in this case that contained some guidance on computing FRAND royalties for using such standards-essential patents (Economist, 11 May 2013). Essentially, he found that Motorola’s request of a few dollars per Xbox unit sold by Microsoft was at least one hundred times too high, given the number of other SEPs involved, and the relative unimportance of the technologies in question to the product. His computations were based on the existence of some patent pools in the same technology area that had associated royalty rates.

It is probably safe to say that there will be many such disputes in the future, unless the firms in question can develop methods such as cross-licensing and the creation of patent pools to deal with situations where their competitors own patents that are essential to the operation of their business, as happened in the semiconductor manufacturing sector.

Space prevents a fuller discussion of the issues associated with patenting in high technology sectors, hold-up, patent quality, the potential for patent thickets, and the litany of problems that have been identified in this area. A useful reference is Shapiro (2001); see also the reports on some of these topics at the EPO Economic and Scientific Advisory Board website (EPO 2012). Although there are many historical examples of the growth of patenting in particular technology areas leading to complaints about the cost of patent search and the presence of “thickets,” the latest version appears to be larger and more pervasive than many of the previous episodes. The problem is that the rise of the internet, digital communications, and digitized information media has led to an explosion of patenting, first in the United States and then in many other countries. In the US, this rise was accompanied by some court decisions that opened the door to software and business method patenting at a time when the patent office was not equipped to handle such technologies. So there is a widespread view that a number of "low quality" patents issued, especially during the late 1990s. Firms faced with this landscape increased their own patent applications, putting pressure on a number of offices and arguably increasing the probability that patents issued that should not have. Figure 11 shows the growth of such patenting in the U.S. The problem is probably worse outside Europe and the UK, but even the EPO has expressed some concern about patent quality and adopted a "Raising the bar" strategy in 2011.

Figure 11: Growth in US software patenting



Source: Presentation by the Open Innovation Network to the Santa Clara High Tech law Institute Workshop on Software Patents

What does all this mean for manufacturing in the UK? The main implication is that competing internationally in ICT technologies requires firms to pay attention to the many technology standards needed, who owns them, and the cost of obtaining licenses to use them. Firms also face the risk that if they are successful outside the UK, they may become the target of patent holders who own patents that are alleged to cover technologies that the UK firms may believe they developed themselves (independent invention). In this, they are no worse off than firms from other countries, although the Apple-Samsung cases suggest that there may potentially be some home bias in litigation (Apple was effectively thrown out of court in Chicago and the UK, while winning a large judgement in Silicon Valley from a local jury trial).

A second and important consideration is that technologically advanced manufacturing firms will inevitably be exposed more and more to the standards essential patent environment as autos and appliances become equipped with wireless communication technology and other digital technology. I discuss the issues that will arise in more detail in the concluding section of this report.

5.4 Unitary patent

The introduction of the unitary patent and the unified patent court in Europe has the goal of simplifying the enforcement of patents in Europe, but the way in which it is being implemented seems to have increased complexity rather than reducing it. The main difficulty is that there has been a reluctance to eliminate the alternative national patent strategy, at least for a transitional period of 7 years, which means that firms have a choice of enforcing existing patents either as a unitary patent, or in the traditional manner in each jurisdiction as a national patent. Given the possibility of differing outcomes in different jurisdictions, this latter strategy may be preferred by some firms, and may also lead to conflicting outcomes, creating confusion for competitors. An excellent discussion of this and related issues is contained on the IPKat blog (Marshall et al., 2013).

Because the unitary patent does not come into existence until it has been ratified by the UK, France, Germany, and 10 other states, there is likely to be some delay in its introduction. The expected date for full adoption in the UK is either 2015 or 2016, according to Alan Johnson, who follows the legislation for CIPA (Johnson, 2013). Johnson also discusses the possible application strategies available to firms under this system as it evolves, although a full understanding of these awaits the precise setting of fees for application, translation, and so forth, something which has not yet happened.

The issue of how the unitary patent and the unified patent court will affect UK firms is a very complex one, and the discussion here is necessarily quite brief. One thing that has caused considerable comment among UK legal scholars is the question of bifurcation, which refers to whether a single court case handles questions of both validity and infringement (as in the UK), or whether these are bifurcated and handled separately (as in Germany). The new unified patent court is expected to follow the German model, although in principle it is not required to. Where this may cause a problem is when the validity decision has not come down before infringement is decided. In this situation, some well-known cases in the past have resulted in findings of infringement of patent later found to be invalid, which is cause for concern. So it will be important to ensure that validity and opposition proceedings are conducted in a timely manner, so that the results are known before the infringement trial.

6. Patent box

The patent box is a name given to a tax policy that offers a reduced rate of corporate tax to income that can be associated with patents. This policy was introduced by the Netherlands and Belgium in 2007, followed by Luxembourg and Spain in 2008 and the UK in 2013. The intent of the policy is to encourage innovative activity and patenting to be located in the particular country that offers it. Economists have critiqued this idea on two grounds: first, given its introduction in a number of European countries, the net effect may be tax competition that simply reduces revenue without encouraging local innovation much. Second, encouraging patenting is not the same thing as encouraging innovative activity and may discriminate against some kinds of innovation. If patenting is costly for society, it is not clear that we want to encourage firms to file for more and lower value patents in order to save on taxes. In addition, allocating income to products covered by patents is problematic and ripe for abuse. The problem here is similar to the one that arises in the case of transfer pricing on intangible inputs.[10]Use of formulaic allocation of profits is helpful, but not a complete solution, as there is still considerable discretion available. For discussion of these issues, see the Treasury consult on the patent box (UK HM Treasury 2011).

In addition to the income allocation problem, it is not at all clear that a patent box has the desired effect of encouraging R&D activity to be located in the country where the patent is taken out, as firms have some flexibility in where they apply for patents, especially in the European system (where the applicant is often the firm in question, and the inventor's address may be a corporate address). As pointed out by Griffith and Miller (2011), European law requires equal treatment of research undertaken within Europe, regardless of the country within it is located. Griffith et al. (2011) have shown that corporate taxes do affect the location of IP, and that in the short run the patent box is likely to encourage patenting in the UK, but that the revenue loss from the lower tax rate is not made up by the fact that there is increased income from patenting. They do not provide an estimate of the possible long run growth effects from having increased patenting located in the UK (or whether any such effects can be expected).

[10] The recent controversies in the US and the UK over corporate taxation of global corporations like Starbucks and Apple are illustrative of the problem.

7. Looking forward

It is a bit of a fool's game to try to forecast industrial trends for more than a few years ahead, but this final section of the report makes some efforts in that direction. The first thing to point out is that although IP protection can be important to the firms that use it, it is probably not the primary driver of manufacturing sector evolution and growth. And although good IP policy is clearly preferable to bad for the purpose of promoting innovation in industry, firms tend to develop ways to mitigate the harms caused by overly weak or overly strong IP protection.

Current trends suggest that manufacturing in the most developed countries will continue to shrink relative to the service sector. Shrinkage of the manufacturing sector *per se* should not be confused with shrinkage of sectors which link to it (especially software and communications, but also transportation and business services), which is unlikely to happen. In particular, trends in the machinery sector broadly defined to include electrical machinery, electronics, optical and medical instruments, and transportation equipment suggest that technical standards and wireless communications will become ever more important. As these types of standards are typically covered by privately held intellectual property rights, there will be increased concern with the problems of licensing in IP and issues associated with "royalty stacking."

In a preliminary report on the findings of their knowledge-based capital project, the OECD (2012) discuss an interesting and problematic consequence of the interaction of the "internet of things" with the current IP and regulatory environment for wireless communication. Consumers are familiar with the use of a SIM-card in their phone that locks them to a particular mobile phone provider but can be changed if they decide to change providers. But when a car or appliance is fitted with one of these cards so that it can communicate with the internet, the card is usually soldered in place to protect it. Changing internet providers on a large number of machines with dispersed ownership would be a very costly undertaking, and in addition, there is no easy way to deal with the problems created by a wireless carrier that goes out of business. The obvious solution is for large transport equipment or appliance-producing firms to run their own wireless networks, but this would encounter regulatory barriers and also requires them to develop expertise in an area in which they have not traditionally operated. We can imagine that this is an area with opportunities for technology-intensive manufacturing but also an area where new modes of accessing standards-related intellectual property will become necessary.

The forward looking strategy of Burberry, a long time British brand, shows how a more traditional manufacturing industry can interact with new modes of product delivery, generating demand for various technological services, and reinforcing the importance of various kinds of IP protection for such brands.[11] Burberry has been a pioneer in the use of Facebook and Twitter to promote its brand and is now live streaming the showing of its collections, taking customer orders in advance of delivery to retail stores. They also have a made-to-order option on their website that allows ordering the iconic raincoat in a wide range of fabrics, styles, and finishing. All of this requires considerable investment in website development, and involves sales directly to the end-consumer, bypassing

[11] "I.T.'s in the Bag," *New York Times*, 18 February 2013. It is interesting to note that the company's founder, Thomas Burberry, was the owner of about 20 patents on outer garments of various kinds issued between 1880 and 1914.

traditional sales channels. At the same time, the made-to-order strategy may be difficult for illegal copiers to imitate.

There are two important evolutions involving copyright that should be mentioned. First, as indicated above, the manufacturing industry for which copyright is most important is the publishing, printing, and reproduction of recorded media industry (ISIC C 18). But the trends in this sector are essentially taking this industry out of manufacturing and into the information industry (sector J). For example, CNN News reported that digital music sales in 2011 were higher than physical sales for the first time.[12] This trend is observable in newspapers, books, magazines, and video of all kinds. The production of video (motion pictures and television) is already classified in the service sector and it is fairly clear that publications and sound recordings will follow. Once there is no physical product, there is no “manufacturing” as conventionally understood. So one trend is easy to see – the most important industry in terms of copyright protection in manufacturing will either disappear over time and the sector J, “Information and communication” will grow correspondingly, or the business of digital reproduction will continue to be incorrectly classified as “manufacturing”.

A second development that has the potential to change manufacturing in unexpected ways is the growth of 3-D printing, which allows the custom creation of objects and parts of objects essentially at will, without the need of a large setup cost to create a new shape. The cost of equipment for 3-D printing is falling rapidly and the technique will therefore be available to a large number of individuals. This development has a number of potential interactions with intellectual property protection. 3-D printing effectively democratizes the creation of physical objects, by individuals who may not be familiar with the patent system or do not wish to incur its costs. Many such objects would not be patentable, of course, but others might be, or indeed they might already be covered by patents. The likelihood of parallel independent invention would clearly increase. The ease of copying a patented object for personal use is also increased, and may be largely undetected. Copyright protection is likely to be used for the CAD/CAM instructions that create objects in the same way it is used to protect software, and one can imagine that there will also be attempts to patent such instructions in some cases.

Weinberg (2010) also points out another area where 3-D printing may lead to tension with patent law. It is legal to repair a patented product, or to reproduce part of a patented product for the purposes of refurbishment. However, reconstructing the product in its entirety from such parts is infringement, although not if it is done over time part by part as the parts wear out. The line between repair and reproduction is therefore rather murky and may become more so with the ease of copying parts.

The implication of all this for the UK manufacturing sector is not immediately clear but a few observations are possible. Increased customization via 3-D printing is likely to create opportunities for manufacturing that is close to the customer, and to increase the technological contribution to the manufacturing of even traditional products. These developments would tend to favour manufacturing in developed economies or at least in economies where the end consumer is located. The ease of copying created by 3-D printing reduces the returns to operating manufacturing at scale, which implies that preventing imitation via a minimum efficient scale requirement becomes less feasible. This fact may increase the importance of using legal means to prevent imitation. At the

[12] http://money.cnn.com/2012/01/05/technology/digital_music_sales/index.htm

same time, the opportunity to customize and build upon another’s design may lead to innovation and new business opportunities. Strict enforcement of patents may hinder this activity. There is a possible parallel suggested here with fair use in the case of copyright in the digital age.

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Appendix A: Use of formal IP protection methods in UK manufacturing

The purpose of this appendix is to supply tables and graphs that describe the current use of formal IP protection methods in the UK manufacturing sector, in order to provide a context for the discussion in the report. The data reported here comes from 4 editions of the UK version of the EU Community Innovation Survey, CIS4 (covering 2002-2004) through CIS7 (covering 2008-2010). Each of these surveys were administered in the year following the 3 year period that the survey covered to a sample of firms drawn from the UK ONS business register. The samples were stratified, and a new sample was drawn for each survey, so there is relatively little continuity of individual firms from survey to survey. For the analysis here, I have restricted the data to firms that report their primary activity as manufacturing (SIC92 between 15 and 36), yielding approximately 3000 firms per survey (somewhat fewer from the last survey, which had some response problems).

Analysis of these data reveal two central facts: 1) the take-up of any type of formal protection is a relatively rare event; and 2) use of one formal IP mechanism is correlated with the use of the others, even after controlling for a wide range of firm characteristics. The latter result suggests that “taste” for IP varies across firms for unexplained reasons. The remainder of this section presents the tables that lead to these conclusions.

Before presenting the numbers, it is important to describe the survey questions on which they are based, as they differ across the surveys. In CIS4 and CIS5, which cover the 2002-2006 period, the questions took the following form:

> For the three-year period 2002-2004 (resp. 2004-2006), please indicate the importance to your enterprise of each of the following methods to protect innovations: patents, registration of designs, trademarks, copyright. The respondent was asked to specify one of none, low, medium, or high.

In CIS6 and CIS7, which cover the 2006-2010 period, the question was about actual use of an IP protection method, rather than about its importance.

> During the 3 year period 2006-2008 (resp. 2008-2010), did your enterprise: a. apply for a patent? b. register an industrial design? c. register a trademark? d. produce materials eligible for copyright? The respondent was asked to answer yes or no to each question.

In what follows, I have analyzed the answers to these two different styles of question separately, as they produce quite different results. The tables below show that firms are much more likely to rate an IP method as of medium or high important than they are to actually use the method. Conceptually, the question about importance should be more satisfactory than the simple use question, since it is likely to correct for differences in size. That is, consider two firms, one large (250 employees) and one small (10 employees), each of which owns a single patent. Both should answer yes to the latter question, but the large firm with only a single patent may not consider patents very important, and hence will answer the first question with a “low”. In practice however, simple regressions of these variables on firm size reveal that they both have approximately the same strong positive relationship to size.

Table A1 shows the results of the IP questions for manufacturing from the four surveys. Approximately 20 per cent of the firms rate each of the IP methods as of medium or high importance to them and there is little difference across the two surveys (CIS4 and CIS5). In contrast, fewer than 10 per cent of the firms report actually using the corresponding IP protection methods during the past 3 years in the CIS6 and CIS7 surveys. Design rights are the least used (about 3 per cent of the firms), whereas patents, trademarks, and copyright are used by about 6 to 8 per cent of the firms. The bottom panel of Table A1 shows the answers to the IP questions weighted by the employment in the firm – in this case, the shares are considerably higher, reflecting the tendency of larger firms to use IP protection. For example, as many as half of the employees in manufacturing are in firms that rate patents as of medium or high importance.

Table A1. IP Importance and use from the CIS 2002-2010
Manufacturing sector

		*Share of firms**		
Years	*Patent*	*Design*	*Trademark*	*Copyright*
1998-2000	15.4%	12.2%	19.1%	14.3%
2002-2004	18.1%	17.2%	20.3%	17.1%
2004-2006	20.6%	21.1%	24.4%	20.2%
2006-2008	6.4%	2.6%	6.6%	7.2%
2008-2010	8.4%	3.0%	8.6%	7.6%
		Employment-weighted share of firms*		
Years	*Patent*	*Design*	*Trademark*	*Copyright*
1998-2000	26.5%	19.8%	32.2%	28.0%
2002-2004	42.7%	36.6%	46.4%	33.6%
2004-2006	51.3%	45.4%	53.5%	41.9%
2006-2008	16.4%	8.2%	17.3%	14.7%
2008-2010	25.0%	12.9%	21.7%	16.6%

*In the first three rows, the share of firms rating the IP method as of medium or high importance is shown. In the last two rows, the share of firms that actually use the IP method over the last 3 years is shown.
Based on 15,166 observations in sample.

Figures A1 (*importance* in 2002-2006) and A2 (*use* in 2006-2010) show how these vary by firm size. In Figure A1, all methods of IP protection have roughly the same importance, with importance increasing steadily as a function of firm size. Almost half of firms with more than 200 employees rate each IP method of medium or high importance to their firm. In contrast, IP use (Figure A2) shows more variability: Use is low for all firms with fewer than 50 employees, and increases substantially for larger firms. Design rights are much less likely to be used by firms of any size, whereas copyright (the only right that does not require registration, and is therefore of lower cost) is more evenly distributed across firms of different sizes. In all cases, use is much lower than the importance ratings would suggest. This result is unlikely to be due to the difference in time period, because the general trend during the decade was an increased focus on IP.

Figure A1: Share of firms rating different forms of IP as of medium to high importance, by firm size, 2002-2006

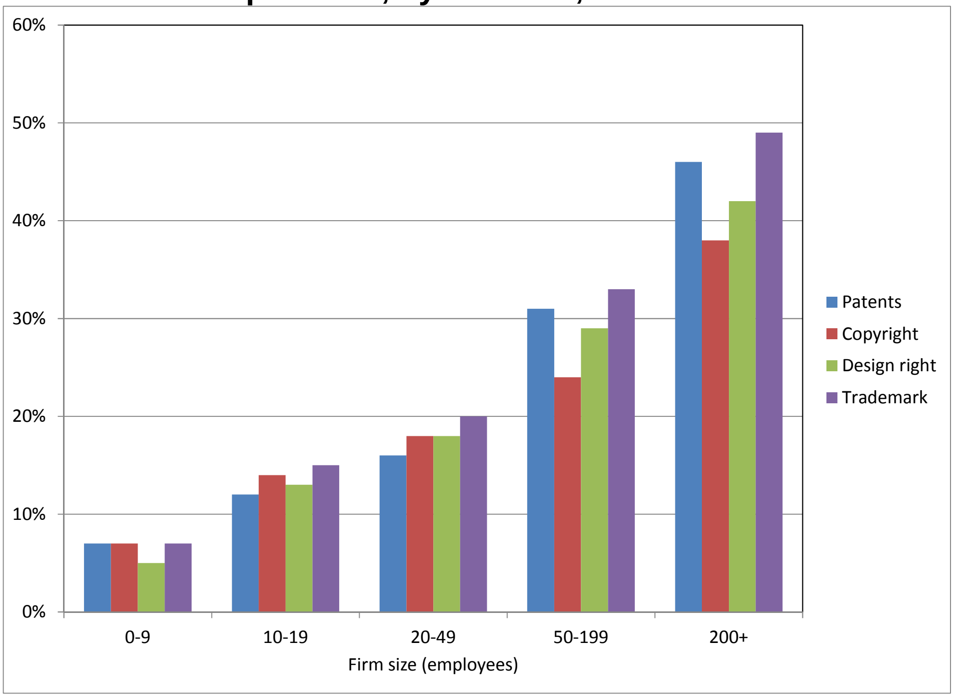

Figure A2: Share of firms using different forms of IP during a three-year period by firm size, 2006-2010

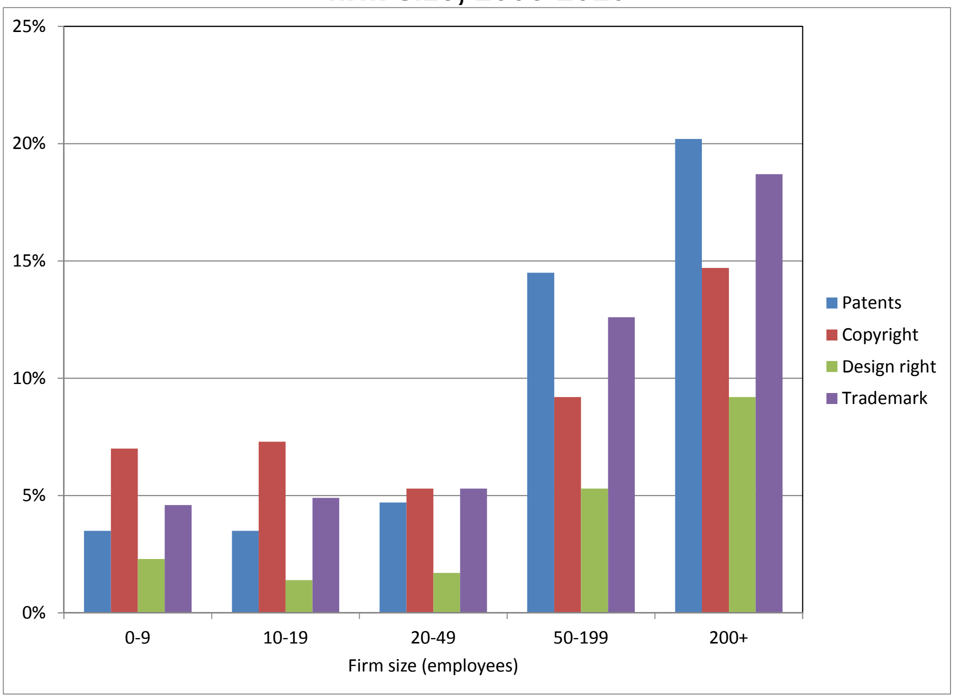

Table 2 looks at how the answers to the IP questions vary by 7 broad industry grouping within manufacturing. These show some variability: patents, design rights, and trademarks are most important to the chemicals and machinery (including high technology) sector and also, but somewhat less, to the transport equipment sector. Copyright is most important to the printing and publishing sector, not surprisingly.

Table A2. Use of Intellectual Property Rights by manufacturing industry

Industry	*SIC2*	*Patent*	*Design*	*Trademark*	*Copyright*
Med-high importance 2002-2006					
Food, beverage, tobacco	15, 16	13.7%	15.7%	24.1%	12.8%
Printing & publishing	22	8.2%	11.8%	15.0%	25.5%
Chemicals, rubber, plastics	23-25	32.2%	26.4%	33.8%	22.0%
Minerals & metals	26-28	14.9%	14.9%	15.2%	12.3%
Machinery, elec, instruments	29-33	28.6%	25.4%	29.4%	24.0%
Transport equipment	34, 35	24.3%	26.7%	25.0%	23.9%
Manufacturing NEC	17-21, 36	14.9%	16.7%	19.4%	15.6%
Applied for 2006-2010					
Food, beverage, tobacco	15, 16	1.6%	0.9%	10.3%	2.6%
Printing & publishing	22	0.8%	0.3%	5.9%	14.1%
Chemicals, rubber, plastics	23-25	8.4%	5.3%	10.8%	5.8%
Minerals & metals	26-28	4.9%	1.7%	4.1%	5.5%
Machinery, elec, instruments	29-33	14.4%	5.0%	9.1%	9.8%
Transport equipment	34, 35	8.6%	2.9%	4.5%	6.7%
Manufacturing NEC	17-21, 36	6.8%	2.2%	8.2%	6.6%

Population weighted, table is based on 15,166 observations in sample.

The apparent similarity of importance and use across IP protection methods within size class and industry suggests that there may also be a common firm-specific factor driving their use. I explore this by estimating a quadrivariate probit regression of the four IP protection methods on firm size, firm age, R&D intensity measured in two ways, whether the firm is an innovator, whether it exports, whether it cooperates with firms outside its group, 2-digit sector, and region, and then examining the correlation of the underlying latent variables. The results are shown in Table A3. The regressions show that the probability of using a particular IP method depends strongly on firm size, R&D intensity, and whether the firm is an innovator but not on firm age. In descending order, the strength of the dependency on size is patent, design, trademark, and copyright. In contrast, trademarks are the least associated with R&D intensity, followed by design, and then by copyright and patents. These results seem plausible if unsurprising.

Table A3. Multivariate probit for the use of IP methods

	Manufacturing – IP use 2006-2010 (5700 observations)			
Independent variable	*Patent*	*Design*	*Trademark*	*Copyright*
Product or process innovator	0.382 (0.071)***	0.371 (0.095)***	0.368 (0.070)***	0.343 (0.074)***
Log (employees)	0.247 (0.023)***	0.208 (0.030)***	0.153 (0.023)***	0.068 (0.025)***
D (employment missing)	1.17 (0.39)***	0.83 (0.38)**	-0.32 (0.50)	0.41 (0.32)
Log (“wide” R&D per employee)	0.123 (0.019)***	0.069 (0.022)***	0.040 (0.017)**	0.120 (0.018)***
Share of “narrow” R&D	0.641 (0.084)***	0.245 (0.103)**	0.280 (0.081)***	0.443 (0.087)***
D (R&D missing)	-0.03 (0.08)	-0.09 (0.10)	-0.228 (0.077)***	-0.02 (0.08)
Log (age in years)	-0.04 (0.04)	-0.01 (0.05)	-0.080 (0.039)**	-0.04 (0.04)
D (age missing)	-0.53 (0.38)	-0.14 (0.35)	0.74 (0.48)	-0.63 (0.31)
D (exports)	0.497 (0.074)***	0.510 (0.094)***	0.551 (0.069)***	0.564 (0.074)***
D (cooperates with other firms, universities, or governments)	0.466 (0.068)***	0.454 (0.091)***	0.327 (0.068)***	0.529 (0.070)***
Chi-sq for 15 industry dummies	108.0 (0.00)***	43.5 (0.00)***	74.7 (0.00)***	91.2 (0.00)***
Chi-sq for 12 industry dummies	13.9 (0.24)	15.9 (0.14)	16.9 (0.11)	29.6 (0.00)***
Log likelihood		-4629.5		

Marginal effects are shown, with robust standard errors clustered on enterprise.

	Estimated correlation matrix for latent variables conditional on regressors			
patent	1.000			
design	0.615 (0.032)	1.000		
trademark	0.471 (0.030)	0.490 (0.031)	1.000	
copyright	0.399 (0.034)	0.435 (0.032)	0.490 (0.032)	1.000
	Estimated correlation matrix for the latent variables			
patent	1.000			
design	0.719 (0.024)	1.000		
trademark	0.585 (0.024)	0.589 (0.024)	1.000	
copyright	0.559 (0.026)	0.548 (0.027)	0.581 (0.025)	1.000

Slightly more interesting is the fact that innovation cooperation of all kinds with other entities (suppliers, customers, competitors, consultants, universities, or government) is associated with the use of formal IP protection of all kinds.[13] This result has also been seen in other work (e.g., Hagedoorn and Ridder 2012 for European firms) and it suggests that firms participating in an “open innovation” model are careful to delineate their ownership of the IP involved, to ensure that they can capture value from the relationship. The correlation matrices at the bottom of Table A3 show that conditioning on size, R&D, innovation, export status, cooperation, industry, and region does very little to reduce the correlation among the latent variables associated with IP use, suggesting that firms differ in unobservable ways in the their “taste” for using IP protection methods, and that when

[13] The innovation cooperation questions across the CIS also differ slightly. For CIS4 and CIS5 (2002-2004 and 2004-2006), a preliminary question as to whether the firm ever cooperated in innovation was asked, followed by questions about with whom and where. In CIS6 and CIS7, the preliminary filter was skipped, and this seems to have led to somewhat higher probability that the firm would answer yes to one of the types of cooperation (about 30 per cent said yes, versus 14 per cent for the earlier surveys). We use only the data for CIS6 and CIS7 in Tables A3 and A4.

they use them, they tend to use more than one. That is, formal IP protection methods are "complements" rather than "substitutes."

To get an idea of the relationship of IP protection choices to actual firm performance, standard productivity regressions with the addition of the IP variables are presented in Table A4. Unfortunately, because the innovation surveys draw new samples every year, these regressions are essentially cross-sectional and cannot be given a strict causal interpretation, nor am I able to explore the timing of the variables. But they do provide a useful summary of the existing relationships. The relationship estimated is the following:

> log (turnover per employee) = f (log capital per employee, log R&D spending per employee, a dummy for firms that do not report R&D, a dummy for export status, 2-digit industry dummies, and year dummies for the different waves of the survey)

Because the IP methods are measured differently in different surveys, results are presented for the whole sample, and for the two internally consistent subsamples (CIS4 and 5; CIS6 and 7). In both cases, the variables considered are dummies: for CIS4 and 5, they measure whether the enterprise considers the method of medium or high importance, and for CIS6 and 7, they measure whether the enterprise actually uses that form of protection.

Table A4. Productivity regressions; dependent variable = Log (turnover/employment)

	2004-2010 (13,253 obs)		2004-2006 (8.154 obs)		2008-2010 (5,099 obs)	
Log (capital/employment)	0.061 (0.006)	0.061 (0.006)	0.061 (0.007)	0.060 (0.007)	0.061 (0.009)	0.061 (0.009)
Log (R&D/employment)	0.090 (0.006)	0.086 (0.006)	0.101 (0.008)	0.096 (0.008)	0.075 (0.009)	0.073 (0.009)
D (no R&D)	-0.073 (0.014)	-0.059 (0.014)	-0.095 (0.017)	-0.078 (0.018)	-0.043 (0.021)	-0.035 (0.022)
Log employment	0.136 (0.006)	0.132 (0.006)	0.125 (0.007)	0.119 (0.007)	0.150 (0.008)	0.149 (0.008)
D (exporter)	0.149 (0.015)	0.141 (0.015)	0.172 (0.019)	0.161 (0.019)	0.123 (0.022)	0.117 (0.022)
D (patent)		0.022 (0.023)		**0.070 (0.027)**		-0.057 (0.036)
D (design)		-0.018 (0.023)		-0.032 (0.027)		0.004 (0.050)
D (trademark)		**0.061 (0.021)**		0.057 (0.025)		0.069 (0.036)
D (copyright)		0.012 (0.021)		-0.010 (0.025)		0.063 (0.038)
Year dummies	yes	yes	yes	yes	yes	yes
F-stat for industry	16.0 (0.000)	16.0 (0.000)	12.4 (0.000)	11.8 (0.000)	9.4 (0.000)	9.6 (0.000)
F-stat for IP methods		4.8 (0.001)		5.2 (0.000)		2.4 (0.048)
R-squared	0.219	0.220	0.201	0.204	0.210	0.212
Standard error	0.650	0.649	0.657	0.656	0.638	0.638

* In 2004 and 2006, a dummy for importance of the IP method; in 2008 and 2010, a dummy for use during the past 3 years.
Standard errors are robust to heteroskedasticity and clustered on the enterprise.

The first column in each panel shows the conventional production function estimates. It is noteworthy that R&D spending has a bigger productivity impact than physical capital, and that being an exporter is associated with 15 per cent boost to productivity. The coefficient of employment suggests some increasing returns to scale (since it is significantly different from zero), although this may be a consequence of the relatively low measured capital coefficient.[14] Non-R&D doers also have slightly lower productivity, as one might expect.

The second column in each panel shows the results when the four dummies of IP importance and use are added to the regression. There is little change to the other coefficients and the IP variables improve explanatory power very slightly. The largest and

[14] It is possible that the low capital coefficient is due to measurement error in that variable.

most consistent relationship is that between trademarks and productivity, which indicates that owning brand names in the form of trademarks is a stable source of profitability for manufacturing firms, other things equal. Patents are positively related to productivity in the first period, but not in the second, possibly reflecting a greater impact of the 2008 downturn on patenting firms.[15] In the second period, production of copyrightable material is positively associated with productivity, at the same order of magnitude as trademarks. From this very rough exploration of the landscape, we can conclude that ownership of some IP rights is related to productivity, but that most firms either do not choose to use IP rights or do not have intangible assets they need to protect.

[15] The low level of the coefficients for patents are partly due to the inclusion of the R&D spending variable, but removing R&D from the regression leaves the collapse of the patent coefficient in the second period unchanged.

Appendix B: Intellectual Property overview

Intellectual Property (IP) consists of inventions, brand names, and artistic creations of all kinds including designs. The term "property" is commonly applied to these creations when a firm or individual chooses to exclude or restrict free use by others via legal means. When owned by a firm, these creations are also frequently described as "intangible assets". However, it is possible that a firm could possess intangible assets that are not protected by registered IP rights or other legal means. It also may be possible that some of the assets protected by IPRs in fact have no value, although such cases are likely to be rare or transitory (since legal protection generally costs something). For the purpose of this report, the focus will be on intellectual property that has some private value and is protected by some kind of legal means.

What are those legal means? In what follows I offer a very brief summary of the IP rights available for use by firms to protect their intellectual property.

Patents

A patent is the legal right of an inventor to exclude others from making or using a particular invention. This right is customarily limited in time, to 20 years from the date of the application submission in most countries. The principle behind the grant of this right is that an inventor is allowed a limited amount of time to exclude others from supplying or using an invention in order to encourage inventive activity by preventing immediate imitation. In return, the inventor is required to make the description and implementation of the invention public rather than keeping it secret, allowing others to build more easily on the knowledge contained in his invention.

For a patent to be granted at the UK Intellectual Property Office (UKIPO) or the European Patent Office (EPO), the application needs to describe an invention (a product, process or an apparatus) that meets three requirements:

1. It must be new.
2. It must describe an inventive step over prior art.
3. It should have industrial applicability.

These requirements are approximately, but not exactly, the same at the US Patent and Trademark Office (USPTO). At that office, the corresponding requirements are described as novelty, non-obviousness, and usefulness. The subject matter definition is "processes, machines, articles of manufacture, and compositions of matter." In spite of the similarity of the definitions, interpretation of the allowable subject matter has been a matter of controversy, and it does differ among the three offices (UKIPO, EPO, and USPTO). Areas of contention include business methods, some aspects of software, and genetics.[16]

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[16] For reasons of space, this review does not cover the detailed regulations in other important patent systems. For information on the Japanese Patent Office (JPO), the Korean Intellectual Property Office (KIPO), and the Chinese Intellectual Property Office (SIPO), see http://www.jpo.go.jp/index_e/patents.html,

Because of their role in protecting inventions that are embodied in new goods and services, patents are arguably the most important form of legally protected intellectual property held by manufacturing firms. This assertion is justified by a body of work that relates firm market value to a range of IPRs and finds a greater premium for patents than for trademark ownership. Manufacturing firms are twice as likely to use patents than firms in other sectors, but the share using patents is still low (about 6.3 per cent in the UK during 2006-2008, compared to about 5.3 per cent in Canada in 2010 and 5.5 per cent in the U.S. during the 1977-1997 period).

Copyright [17]

Copyright law originated in the United Kingdom from a concept of common law (the Statute of Anne 1709), and became statutory with the passing of the Copyright Act 1911. The law gives the creators of literary, dramatic, musical, artistic works, sound recordings, broadcasts, films and typographical arrangement of published editions, rights to control the ways in which their material may be used, covering broadcast and public performance, copying, adapting, issuing, renting and lending copies to the public. In many cases, the creator will also have the right to be identified as the author and to object to distortions of his work. Copyright is an automatic right and arises whenever an individual or company creates a work; it therefore does not require registration and this means that data on copyrights is hard to obtain. To qualify for a copyright, a work should be regarded as original, and exhibit a degree of labour, skill or judgement. Copyright covers the expression of an idea, but cannot protect the idea. In this it is very different from a patent. In the UK, the lifetime of a copyright varies depending on the type of work in the following way:

Table B1: Length of copyright protection by type of work

Literary, dramatic, musical or artistic works	70 years from the end of the calendar year in which the last remaining author of the work dies
Same, where author unknown	70 years from end of the calendar year in which the work was created, or first made available
Sound Recordings and broadcasts	50 years from the end of the calendar year in which the work was created or first released.
Films	70 years from the end of the calendar year in which the last principal director, author or composer dies
Typographical arrangement of published editions	25 years from the end of the calendar year in which the work was first published.
Broadcasts and cable programmes	50 years from the end of the calendar year in which the broadcast was made.
Crown copyright (works made by an officer of the Crown)	125 years from the end of the calendar year in which the work was made.
Parliamentary Copyright (work that is made by or under the direction or control of the House of Commons or the House of Lords)	50 years from the end of the calendar year in which the work was made.

Because copyrights do not have to be registered in general, it is difficult to form a very precise picture of their use or value in different sectors. In the case of manufacturing, one might expect that they would be important for the printing and publishing industry, but

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http://www.kipo.go.kr/kpo/user.tdf?a=user.english.html.HtmlApp&c=92000&catmenu=ek03_01_01, and http://english.sipo.gov.cn/ respectively.

[17] This section based on information from http://www.copyrightservice.co.uk/copyright/p01_uk_copyright_law

perhaps less important for other sectors. Nevertheless they do appear to be used by many manufacturing firms, as the data in the appendix show.

Trademarks

A trademark is a logo, word, or possibly another identifiable item such as a sound, shape or even a color that is capable of being distinguished when used in the market. Trademark rights prevent a seller from free-riding off another's reputation for quality. In this, they are distinguished from other forms of IP, since they are intended to protect consumers, rather than a firm that produces an invention or original work. Nevertheless, because they reduce free-riding by competitors, they are associated with firm value, as has been shown for the UK by Christine Greenhalgh and co-authors.[18]

Design rights and registered designs

In the UK, a registered design is legally defined as "the appearance of the whole or part of a product resulting from the features of, in particular, the lines, contours, colours, shape, texture or materials of the product or ornamentation."[19] If a design is registered, the owner has exclusive rights in it for up to 25 years. This means he or she can exclude others from "making, offering, putting on the market, importing, exporting, using or stocking for those purposes, a product to which the design is applied." If a firm fails to register a design, it still retains some rights, but they are more limited. Protection is limited to the United Kingdom (UK), and lasts either 10 years after the first marketing of articles that use the design, or 15 years after creation of the design - whichever is earlier. For the last 5 years of that period the design is subject to a Licence of Right (obligation to license). The recent disputes over the design of computer tablets involving Apple Inc. and Samsung have demonstrated the high valuation of some design rights for consumer goods manufacturers. At least in the United States, one case led to a jury settlement of one billion dollars in favor of Apple, although this was recently overturned and the amount cut in half. A similar case resulted in a victory for the defendant (Samsung) in the UK. Issues related to the uniqueness of the design of electronic products and the extent to which they can be protected are by no means settled.

Trade secrecy

An alternative to patenting some innovations is protecting them via secrecy. Obviously the success of this strategy will depend on the ease with which the innovative product or process can be reverse engineered. Trade secrecy can also be used to protect things that not protectable in other ways, such as business plans and customer information. Hall et al. (2011) found that secrecy was rated as important by more firms than any of the formal IP protection methods, probably because of its relative simplicity and low cost. This report focuses on formal IP since it is more easily monetized directly, but it should be kept in mind that many firms find it convenient to protect their intangible assets by secrecy and to extract value from them using means other than formal IP protection.

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[18] Greenhalgh and Longland (2005); Greenhalgh and Rogers (2012).
[19] http://www.ipo.gov.uk/types/design/d-about/d-whatis.htm

Foresight
1 Victoria Street
London SW1H 0ET
www.bis.gov.uk/foresight
URN 13/822