

**TRENDS AND DISTRIBUTION OF INTELLECTUAL PROPERTY:
UK AND EUROPEAN PATENTS AND UK TRADE AND SERVICE
MARKS 1986-2000***

Christine Greenhalgh, Oxford Intellectual Property Research Centre, St. Peter's College

Mark Longland, Oxford Intellectual Property Research Centre, St. Peter's College

Derek Bosworth, Emeritus Professor, Manchester School of Management, UMIST

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* Corresponding author: Christine Greenhalgh, Oxford Intellectual Property Research Centre, St. Peter's College, Oxford, OX1 2DL www.oiprc.ox.ac.uk E-mail: christine.greenhalgh@economics.ox.ac.uk

ABSTRACT

We begin by outlining two different categories of intellectual property, examining the nature and relationship of trade marks to patents and posing the question: do trade marks reflect intellectual property (IP) with the potential for beneficial spillovers, or merely private intangible assets? We document the acquisition of four types of IP for the UK domain; three of these measures of IP (patent publications via the European Patent Office and applications for UK trade marks for goods and services) show some similarity in their cyclical fluctuations and rising trends, but with variations by patent or trade mark class indicating the major patterns of technological activity and product demand. However very different time trends were observed for patent publications via the UK Patent Office, which fell sharply to 1993 before subsequently increasing although not reaching the levels seen in the late 1980s.

We then track the IP performance of UK firms, using data tracing IP ownership, in two panels of UK production firms created for the periods 1986-95 and 1996-2000. This confirms that falling rates of British patenting in the earlier period were not fully compensated by rising applications via the EPO. However, trade mark applications rose, especially during the mid to late 1990s.

We also investigate the role of firm size in the generation of both kinds of intangible assets: generally these data refute the Schumpeterian hypothesis that size promotes innovation. We find smaller firms are disproportionately active in acquiring IP assets via the UK Patent Office and even via the EPO there is no strong evidence that size matters for patenting propensity. We conclude by examining the policy implications: our findings support the recent introduction of R&D tax credits for firms of all sizes and the continuation of low British patent fees for new applications.

Keywords: intellectual property, patents, trade marks, firm size.

Executive Summary

Aggregate trends in patents and trade marks:

1. This study has highlighted and contrasted the strong positive trend in European Patent Office (EPO) patent publications with a strongly negative trend in UK Patent Office (UKPO) patent publications.
2. While the total number of patents with coverage in Britain rose, there was a significant decline in the share of patents held by UK residents.
3. This fall in UK-owned patent protection includes technology fields involved in product areas which have historically been important to the production of high technology goods in Britain.
4. Chemicals moved down the rank order in UKPO patents, where the number of patents published more than halved, in contrast to remaining a principal group for patents published via the EPO, where the number of Chemical patents rose by 83%.
5. Domestic performance was relatively stronger in trade marks and applications via the UK generally rose strongly after 1993.
6. The trade mark classes enjoying the highest rates of expansion over the whole period, were predominantly service marks, for which registrations latterly exhibited explosive growth, expanding seven-fold from 1993 to 2000.

Trends in IP ownership by panels of UK firms:

7. To see whether these trends were common to individual firms in key production sectors (and not due to the changing composition of industry or firms' decisions about patenting routes), we constructed two panels of UK production firms for 1986-95 and 1996-2000.
8. The panels of firms were medium to large sized in respect of their sales and employment, mostly listed on the stock market and having many subsidiaries. The counts of IP assets for these panels of firms were generated by a complex process of search and matching of company names from the various sources of IP records, in order to allow for the fact that

IP assets could be registered under a variety of names of subsidiary and associate firms within the group.

9. There was a dramatic decline in total patents with coverage in the UK published by the first panel of surviving large British firms from 1986-95; these negative trends levelled out in the mid-1990s but did not reverse significantly in the second panel.
10. This decline arose as no increase in EPO patents was observed which could compensate for the fall in UKPO publications. The British firms in this study were thus failing to keep abreast of the rising rate of patenting activity by their competitors via the EPO in the period 1986-2000.
11. In contrast, trade mark applications by the second panel of British firms rose very strongly from the mid-1990s, with the average number of marks sought per firm reaching twice that seen in the earlier period.

Correlation between activity levels in types of IP

12. Firms which were active in patenting via the UK were also more likely to be active in patenting via the EPO and in filing trade mark applications (and vice versa).
13. A significant proportion of firms had no patents published via the UK or EPO routes in five years (42% of firms 1990-94 and 53% in 1996-2000). In contrast, more than two thirds of firms had made some trade mark applications in each five-year period.
14. These findings and the trends noted above suggest that British firms saw higher rates of return in increasing product variety backed by trade marks than in major product or process improvements protected by patents.

Evidence on firm size and intellectual property:

15. Evidence on the relationship between IP acquisition and firm size, whether measured by sales or by employment, generally showed a higher propensity for both UK patent and UK trade mark protection by the smaller firms in these panels.

16. EPO patenting was more frequently proportional to sales, but EPO patents per worker fell with firm size as measured by employment.

Implications for policy and research

17. Despite the recent introduction of the UK R&D tax credit, the rate of development of significantly novel innovations protected by patents may not rise if firms persist in the strategy of increasing product variety protected by trade marks, as evidenced in this study.

18. Further study is needed into the total social returns to different types of innovation by firms, comparing novel innovation protected by patents with brand proliferation protected by trade marks. If the social returns to novel innovation are much larger, then Britain may gain little from an emphasis on brand proliferation by its domestic firms.

Introduction⁺

In any era of rapid technological change, firms compete to retain and develop their markets by the continuous introduction of new products, both goods and services, embodying novel components and often produced using new techniques. In other studies (Greenhalgh and Longland, 2002, 2001; Greenhalgh et al., 2001b) we have demonstrated that such technological activity in firms is positively associated with the firm's level of output, wages and employment. In earlier research (Greenhalgh et al., 1994 and 1996) we showed that the international competitiveness of UK industry, as measured by net exports of a wide variety of sectors, was positively associated with measures of innovation, including patents. These results demonstrate that this competition between firms is not a zero-sum game between winners and losers, but rather that it has net benefits at the aggregate, macroeconomic level.

Integral to the process of competition for domestic and international market share by firms is the acquisition of a portfolio of intangible assets, including intellectual property, commercial reputation and customer loyalty or goodwill. To study firm strategy and behaviour we need a variety of measures of such activities, but hitherto the emphasis in the empirical analysis of innovation has been on the inputs to the conduct of R&D (measured by expenditure) and on outputs in the form of intellectual property (IP) registered as patents.

In legal texts on intellectual property (e.g. Cornish, 1999), three main forms of such property are identified: patents, copyright, and trade marks. Copyright is difficult to address empirically as it is not subject to a registration procedure which can generate economic statistics. However, despite trade marks being registered and recorded in a similar manner to patents, very little attention has been paid to trade marks in the economics literature. Certainly the validity of describing trade marks as true indicators of IP can be questioned and we address their nature and relationship to patents in the first part of the paper. With their

⁺ The development of a database for 1986-95 was undertaken as part of an ESRC project 'The Economic Role and Value of Trade Marks' (grant number L325253036) and a first version of this paper was produced as Greenhalgh, Longland and Bosworth, 2001a. The extension of the database for the period 1996-2000 and the updating of findings reported here has been done under the research project 'The Extent and Value of Intellectual Property in United Kingdom Firms' financed by the UK Patent Office. In addition, we are grateful to the UK Patent Office for access to the archive of UK patent publications, to St. Peter's College for accommodation and administrative services for these projects and to Mark Rogers for help with the data analysis.

hybrid nature, between intellectual and commercial assets, they have the advantage of being registered by a broad range of companies, including those in the service sector, which rarely make use of the patent system, but which form such a large and growing part of economic activity in advanced industrial economies. We discuss how trade marks are related to the establishment and maintenance of a portfolio of key products or brands, so forming part of the arsenal of tools for non-price competition.

The empirical work presented here begins by investigating the scale of intellectual property and the trends in patent and trade mark acquisition in the UK and of patent publications via the EPO, presenting data for up to one and a half decades from 1986 to 2000. We examine how similar are the profiles of IP activity in different geographical domains. While the coverage of trade marks is broader and more detailed than for patents, we attempt a matching aggregation of trade marks relating to goods in order to compare patent and trade mark activity. We also document the overall balance of trade mark application between goods and services. This analysis enables us to see which were the sectors of greatest technological activity and product development, fed by both scientific advance and consumer demands.

We next examine both types of IP for two panels of selected UK companies. These samples relate to large firms (generally parent firms with subsidiaries and associates) operating in the production sector from 1986-95 and from 1996-2000. Due to a large amount of turnover in firm names as a result of mergers and acquisitions, the number of firms which had survived in the same form for all fifteen years is rather small, so larger samples were obtained by splitting the time period. We look at how these surviving firms have fared in terms of IP acquisition and to what extent their experience mirrors or departs from the patterns and trends in the overall data. We also examine to what extent the same or different firms are engaging in the acquisition of patents and trade marks.

An important debate in the literature since it was raised by Schumpeter (1942) has been the nature of the competitive market under a process of continuing product and service innovation. Schumpeter and others have long recognised the tension between large firm size and market share, thought necessary to finance risky R&D and to profit from product development, versus the anti-trust leanings of governments aiming to promote consumer welfare via competition. In the last section of the paper we present further evidence concerning the relationship between firm size and firm performance in acquiring patents and trade marks.

Intellectual property and market efficiency

Economists see property rights as a necessary basis for private markets to function effectively, by permitting various agents to undertake market transactions backed by enforceable contracts. Markets characterised by unpriced externalities give rise to distortions and hence to non-optimal outcomes; in particular positive externalities lead to under-investment in the activity generating the benefits. One solution is to define and award property rights which permit pricing and contracting to arise in respect of the previously external effects.

The award of patent rights can be justified as a (second best) solution to the absence of incentives to invent if all novelty and invention were immediately to become open to appropriation by competitors. That the patent system is itself non-optimal is recognised from the foundation work of Arrow (1962), who examined investment in information in the market economy and concluded that: “Any information obtained ...should, from a welfare point of view, be available free of charge ...This ensures optimal utilisation of the information, but of course provides no incentive for investment in research.”

To qualify for patent protection an invention must be new (never publicised before), must involve an inventive step (not obvious even to experts in the field) and must be capable of industrial application. One key feature of patents, limiting abuse of monopoly power under the system, is their limited term of 20 years. Another is the requirement to disclose the invention: the patent applicant is required to document the precise substance of his invention in order to satisfy the patent examiner about the novelty and non-obviousness of the inventive step and this information enters the public domain even before any patent is granted. This not only eliminates unnecessary duplication of research but also performs an important teaching function for subsequent generations of inventors, who can move quickly into new areas of research building on the work of earlier inventors.

None of these broad characteristics - of incentive to invent, of temporary monopoly, of novelty, or of teaching, apply to trade marks. Even so trade marks are classified in the legal literature as a form of IP. There is certainly a question for lawyers as to what kind of property right these are. For example Cornish (1999) says that: “Patents give temporary protection to technological inventions and design rights to the appearance of mass-produced goods;

copyright gives longer-lasting rights in, for instance, literary, artistic and musical creations; trade marks are protected against imitation so long at least as they continue to be employed in trade... 'Intellectual Property' is the term used in this book for the whole field. The term scarcely describes trade marks and similar marketing devices; but it has now acquired international acceptance."

What is a trade mark? According to the UK Patent Office's Internet website: "A trade mark is any sign which can distinguish the goods and services of one trader from another and be represented graphically. A sign includes words, devices (logos) three-dimensional shapes and packaging, and even sometimes sounds and smells. It is therefore a 'badge' of trade origin. It is used as a marketing tool so that customers can recognise the product of a particular trader." It should be noted that the extension of trade marks to shapes, sounds and smells only arrived with the 1994 legislation. Service marks are also fairly new in the UK, having been introduced ten years earlier; but all types of trade marks can continue indefinitely, subject to renewal fees and as long as the owner continues to trade in the relevant products and their marks do not become generic.

What function is served by the award of infinite duration property rights in the form of trade marks? Firth (1995) argues that for both goods and services, "trade marks and brand names provide important information as to the nature and origin of these products. Such information is essential to the functioning of a competitive market." Both Firth (1995) and Cornish (1999) identify three ways in which trade marks function: to guarantee commercial origin, to indicate quality, and to serve as a vehicle for advertising. Firth admits, quoting the EC Commission, that only the origin function is universally recognised as the proper object of protection by registration, as the product quality and characteristics are not legally guaranteed.

Trade marks can thus serve to signal the source of the product and thereby simultaneously promote and protect the reputation of both the company and its products. Promotion takes place by repetitive product labelling and protection by preventing false adoption of the same label by other producers. Does this have an economic justification, in parallel to the need for patents, helping the economy to get closer to a socially correct amount of investment in innovation, including product variety?

Certainly innovation is often characterised by rapidly expanding choice for buyers; in the case of final products for personal consumers this arrives both as a denser spread of products (expanding product variety in the horizontal dimension) and as a continuous increase in product quality via product upgrading. Both these dimensions of product competition, brand proliferation and quality ladders, have been extensively analysed as underlying micro-foundations of the growth process (Grossman and Helpman, 1991).

These authors demonstrate that increasing brand proliferation (horizontally) is unambiguously beneficial to society as a whole, taking account of the better matching of consumer preferences, netting out the market gains and losses of competing producers, and recognising that the development of each new product adds to general knowledge about production. In contrast and perhaps surprisingly, increasing product quality cannot always be demonstrated to be welfare improving. The potential private gains to firms of introducing new qualities, eliminating the goods of competitors by making their products entirely redundant, can sometimes cause the process of quality competition to run too fast. Firms whose products are outmoded shortly after they have been introduced can lose more than is gained by the newly ascendant firm and its consumers, due to the high duplicate cost of R&D that has been undertaken for product development.

Whichever type of innovation occurs, in this proliferation of choice there is an information problem for consumers and without signals of product quality they may not make informed choices. The use of a trade mark can thus be seen to improve domestic market efficiency by informing the customer choice process in a relatively inexpensive manner. Although firms will certainly use other means, such as public advertising, this is always going to be more resource using than the trade mark system, which may also be useful in the promotion of sales abroad to buyers who are further away from the channels of media communication which carry advertisements.

A large amount of industrial output is supplied in the form of intermediate goods to other firms and sectors: thus gross output is around twice the level of value added per annum in the UK and this figure has been rising due to increased use of specialist suppliers (Gregory and Greenhalgh, 1997). It could be argued that business purchasers will pay as much attention to input prices as to brands, but even these customers may value a product quality signal to ensure reliability of inputs. Of course a trade name or mark does not have to be registered to enjoy protection against infringement. The law of passing off protects against others using

any mark active in the course of a firm's trade. However the use of the registered trade mark system assists firms in respect of actual or potential legal actions against infringers.

Another question which may be asked is whether trade marks are linked to other forms of IP in ways which help these systems to function, or in ways which might be construed as anti-competitive. One view is that, if trade marks and the law of passing off did not exist, it would be necessary to invent them as a support system for the effective implementation of intellectual property ownership in the form of patents and copyright. It would be extremely difficult to trace infringements by pirates if any trade mark could legally be adopted freely. Another idea is that brand names are used to promote continuance of customer loyalty where the patent is expiring and generic substitutes are about to enter the market. A further link is to copyrighted material where either books or films have created characters, which later form the basis for tangible products, such as Mickey Mouse and Winnie the Pooh, in novelty toyshops. While the first link is clearly a plus for social efficiency from the use of trade marks, both the second and third linkages look suspiciously like zero-sum rent-seeking activity, rather than welfare-enhancing quality signalling.

To strengthen the information content of marks in respect of product quality, we might ask is there a possibility of creating a super class of trade marks by linking marks to other forms of quality certification of firms and products? Two methods already exist within trade mark law for enhancing the aspect of quality signalling while still offering power to small producers and new market entrants. These are the special categories of certification marks and collective marks. The first special mark relates to qualities of products which can be objectively verified, and yields an additional mark; examples are British Standards Institution Kitemarks, and CE for Europe. The difficulty is whether consumers know enough about the defined qualities and their testing to be informed by this further mark. The collective mark offers an opportunity for groups of independent suppliers to register their association and, in effect, to derive economies of scale from their trade mark. Such a mark carries no further quality signal than that derived from acceptance as a member of the association, which may be easy or difficult to join; this system is also used by non-commercial associations.

If trade marks are to be an effective signal of product quality and reliability then can they do this fairly and efficiently under the present system? A registered trade mark has value to the extent that it reflects an existing reputation for quality based on customers' knowledge of previous products. While this can be established by long experience of use by customers, it is

also linked with historic trade promotion and product advertising. There seems to be a degree of circularity here, favouring the incumbent trader. What opportunities do new entrants have to displace the incumbents' brands? A new trade mark can be registered, but what commercial or informational value does it have? Do they have to wait for an existing mark to turn sour, which can happen for example if customers decide they do not like the production techniques employed? Trade marks, far from being "essential to the functioning of a competitive economy", may have become part of the complex web of barriers to entry erected by oligopolistic firms. Nevertheless, before we can make judgements about their precise role we need documentary evidence about the relative importance of these intangible assets in comparison with patents.

Empirical dimensions of patents and trade marks

We now turn to documentation of the level and trends in such IP acquisitions from the mid-80s to the end of the century. We begin by looking at trends in IP protection by all applicants of any nationality in Britain (patents and trade marks) and Europe (patents via the EPO). The analysis of panels of UK firms will then be analysed and assessed against these trends to see whether British firms are doing as well as other nationality applicants.

UK patent publications 1986-2000

Table 1 shows the annual levels by International Patent Classification (IPC), for all patents published by the UK Patent Office (UKPO) from 1986 to 2000. The striking feature of these statistics is that total annual publications fell every year from 1986 to 1993. Patent publications then rose slowly until 1997 reaching a plateau during the late 1990s. By the end of the fifteen-year period, total annual publications had still fallen by 21% compared with the level in the mid-1980s.

Table 1 also contains statistics for the eight major sections of the International Patent Classification: Section B: *Performing Operations; Transporting* was the largest individual section while D: *Textiles; Paper* was the smallest individual section for each year during 1986 to 2000 inclusive. The number of sections for which coverage was claimed per publication rose very slightly but steadily from 1.12 in 1986 to a high of 1.18 in 1998.

Figure 1 shows that the initial sharp decline affected patents in all of these eight major sections. The largest proportionate falls were in C: *Chemistry; Metallurgy*, down 56% between 1986 and 1993, and D: *Textiles; Paper* (down 55% although from a small base); big falls were also recorded in F: *Mechanical Engineering, etc.*, (down 39%) and also in Section B: *Performing Operations; Transporting* (down 31%), while the least affected sections were H: *Electricity* (down 14%) and E: *Fixed Constructions* (down 12%). The recovery was driven by patents in three sections: G: *Physics*, H: *Electricity*, and A: *Human Necessities*, with most other sections remaining flat, including C: *Chemistry; Metallurgy*.

This naturally leads us to ask: was there less patenting via the UK route by both British and foreign firms due to the developing opportunity to obtain coverage in Britain via the European Patent Office? According to the UK Patent Office website there are considerable advantages to British firms in applying for a UK patent before seeking protection abroad (inexpensive search, establishment of a priority date, security clearance for filing abroad) so the use of the UK route is unlikely to have been quickly shunned by local firms. We can investigate whether the amount of interest in the UK as a market by foreign firms has declined, but again this seems unlikely given the strong trends in inward foreign direct investment during this period. The most likely cause of the fall in UK patent publications seems to be that there were fewer patentable inventions by British manufacturing firms. We investigate this hypothesis below in the section devoted to panels of UK firms.

European patent publications 1986-2000

In sharp contrast to the UK figures, patents published by the EPO more than doubled between 1986 and 2000 (Table 2 and Figure 2), with over 90% of these designating Britain in their coverage. The rank order of patents by IPC section is generally similar in the UK (Figure 1) and Europe (Figure 2). Even so the rankings differ in two major respects between the UKPO and the EPO figures: C: *Chemistry; Metallurgy* was first in 1986 in EPO patents and, whilst it fell to 5th place by 2000, the number of patents is quite similar between all of the top 5 categories, having risen very sharply. In the UK statistics, C began in 6th place falling to 7th by 1991, rising slightly to 6th in 1992, but falling back to 7th in 1993, the position it held thereafter. The second contrast is for F: *Mechanical Engineering, etc.*, which via the EPO was placed 6th throughout the sample period, but which began via the UK as the 2nd most important category, although falling to 5th place by 2000.

Both Patel and Pavitt (1987, 1995) and the Department of Trade and Industry (1994) had previously identified the Chemicals sector as one of the few areas of technological advantage enjoyed by the British economy in comparison with her major trading partners. This makes it important to try to identify why patenting via the British route fell so sharply and in particular what caused the rapid fall in Chemicals. One possibility is that because Chemical producers' returns to inventions depend so heavily on acquiring intellectual property, the overall rate of movement to patenting via Europe was faster for these firms than for those in other sectors of activity. We explore this issue below in the results for the fixed panel of firms. However in an earlier paper we noted that the number of publications of applications from British firms and individuals hardly rose at all in this period (Table A1 of Bosworth et al., 1996) and the increase in EPO patenting activity was very much driven by applications from Germany, the US and Japan.

Patent protection in the UK by residents and others

As well as the two routes noted so far, patenting through the UKPO, or through the EPO designating the UK as a territory in which the patent should apply, there is a third method available to secure protection in the UK through the Patent Cooperation Treaty (PCT). However any PCT application is forwarded to (and if successful eventually granted by) either the UKPO or the EPO. The World Intellectual Property Organization (WIPO) publication "Industrial Property Statistics" includes counts of patent grants via all these available routes and the eventual UKPO and EPO counts are broken down into those granted to residents and non-residents. Table A1 gives details of all patents granted to residents and non-residents for the years 1986-2000.

From these data we can observe that the total number of patents granted with effect in the UK rose by almost 30% between 1986 and 1993, reflecting growing interest in gaining patent protection for the UK market. Against this trend, the lack of increase in the number of patents held by UK residents is in sharp contrast: the absolute number of patents granted to UK residents fell by 17%. The overall rise was driven by a rise of 38% in the number of patents granted to non-residents during this period. The share of all patent grants held by UK residents thus fell from over 16% in 1986 to 10.5% by 1993. During the rest of the 1990s the absolute number of new patents fluctuated, although generally it was above the 1993 level, but the share of new patents held by UK residents remained fairly steady at around 10 or 11% of total grants, with a small rise in the UK share in 2000, to 12.4%. These figures point

directly to the view that UK firms were not keeping pace with foreign competitors in respect of patenting from the late 1980s..

British trade marks 1989-2000

We now turn to our second type of intellectual property. We generated our record of historical UK trade mark applications using Marquesa CD-ROMs (Search Systems Ltd., 1996 and Marquesa Search Systems Ltd., 2002). The first source detailed all applications made in the previous eight years or so, along with earlier applications, which had not “died” (been allowed to lapse, or been abandoned) before the start of this time frame. In constructing evidence on flows using the longest available fully documented period, we were thus restricted to considering new applications made between 1989 and 1995 from the first source, but we could retain a count of the stock of “live” trade marks at 1989 taken out in earlier years. The remaining years, 1996-2000, of new trade mark applications were derived from the second source.

Under the Nice Agreement trade marks were classified, during the main sample period, into 42 classes, of which 34 related to goods and only 8 related to services. This gives a much greater amount of detail for measurement of marks for goods, which is not in proportion to the weight of goods production in the economy, as the service sector has grown to be so much larger than manufacturing in its share of both value added and employment.

Considering all goods marks (classes 1-34) versus all service marks (classes 35-42) using figures from Appendix Table A2, goods marks accounted for 94% of pre-89 surviving trade marks, for 82% of applications in 1989, for 77% of applications in 1995, and for 59% of applications in 2000. Quite clearly, goods classes account for a much larger percentage of the total marks throughout the period, but at the same time the rate of growth of applications from 1989 to 2000 was far greater in the service mark classes than in the goods mark classes. However the period 1989 to 2000 must be regarded as two smaller sub-periods: 1989 to 1993, and 1994 to 2000; the first of these sub-periods saw trade mark applications fall by 15%. Of all 42 sectors, 37 were smaller in 1993 than 1989, and only five were larger, so all the expansion came in the period after 1993.

The reasons behind the differential rates of growth are certainly worthy of investigation. The Trade Marks Act 1994, which came into force on 31 October 1994, enabled shapes,

containers (including 3D marks), sounds and smells to be contenders for registration, when previously such protection was unavailable. Given that the two most enlarged goods sectors were 33: *Wines and Spirits* and 32: *Light Beverages* – it seems likely that the introduction of the Trade Marks Act 1994 encouraged large numbers of applications seeking protection of bottles, packaging and cans from the drinks industry. Although there is now a Community trade mark, which gives protection for the whole area of the European Community, applications for these marks could not be made until 1996. Hence during the period to 1995 this was not an alternative route for acquiring protection for trade marks in the UK.

The classes enjoying the highest rates of expansion over the whole period, were predominantly service marks; applications exhibited explosive growth, expanding by a factor of seven in the seven years to 2000. Of the eight classes the fastest rates of increase were in 38: *Communication*, which expanded by a factor of almost twelve, closely followed by 35: *Advertising and Business*, with 41: *Education and Entertainment* also above average growth. Even so, 42: *Miscellaneous Services* began and ended as the most frequent class of service mark.

So were the legal changes in 1994 also responsible for the growth in service mark applications? Service marks had first become available ten years earlier, but perhaps the sharp rises in applications was partly due to the publicity given to the new Act. Even so the need for such marks undoubtedly reflects the rapid growth of output by these service sectors, their rising rate of product innovation, and their increased supplier linkages with other sectors following privatisation and the wave of contracting-out of services by manufacturing firms (documented in Greenhalgh and Gregory, 2000).

An important and plausible factor which may explain the depressed rate of UK trade mark applications in the early 90s is the impact of the business cycle: Britain experienced a very sharp recession with falling real GDP in both 1990 and 1991, while in Europe the recession was a couple of years later. In these circumstances firms are likely to delay the timing of new product launches until there is an upturn in their main markets. An earlier study of innovations in the 60s and 70s by Geroski et al. (1996) has demonstrated cyclical sensitivity in the rate of innovation. Their evidence and ours both point to the possibility of delays in innovation affecting product quality (or non-price competitiveness) during periods of recession, which can adversely affect economic growth and external trade performance.

Comparing UK patents and UK trade marks for goods

Patent counts by IPC section and trade mark counts by international trade and service mark class, enable one to gain an indication of the importance of both types of IPR for different parts of the economy. Unfortunately, the structure of the two classifications is not the same. This makes it difficult to directly answer questions such as: Are patents, or trade marks more “important” in the production of commodity type x? To consider this issue it is necessary to equate the two classifications in some way. For exploratory purposes, we assigned each of the 34 trade mark classes relating to goods uniquely to an IPC section and these sub-aggregates formed the basis for Table 3/Figure 3 for the UK. (For the mapping see Appendix Tables A3 and A4; note that Table 4 and Figure 4, for service classes of trade marks, are drawn directly from Table A2 with no further aggregation.) The mappings were established by comparing the International Classification (Nice Agreement) trade mark descriptions to the descriptions of the IPC sub-sections and classes within sections of patents. The major problem encountered was that we could not distinguish G: *Physics* from H: *Electricity* as elements of both were registered as trade mark class 9. For purposes of comparison it was thus necessary to add the G and H groups of patents together.

In terms of trade mark applications relating to goods, Table 3 and Figure 3 show that the largest group corresponded to A: *Human Necessities*. This group represented over a third of a million “live” marks, of which more than two hundred thousand applications were made between 1989 and 2000. The second largest application group during the same period was G+H: *Physics and Electricity*. However on including historic stocks of marks, the second largest group would be C: *Chemistry; Metallurgy*, with 145,400 “live” applications, of which 47% were long-lived applications filed before 1989. The two smallest groups for marks were, as for UK patents in most years before 1993, E: *Fixed Constructions* and D: *Textiles; Paper*.

Over the period 1989-2000 our comparisons indicate that UK trade mark applications for goods are much more numerous in comparison with local patent publications, showing a ratio of 3.0 for applications made via the UK Patent Office (ratio of sums of A-H values). The ratio of UK marks to UK patents was much larger in the areas of A: *Human Necessities*, C: *Chemistry; Metallurgy* and D: *Textiles; Paper*. At the other extreme, for E: *Fixed Constructions*, UK patent publications are relatively more numerous than UK trade marks. The major difference in rank ordering of the goods classes between patents and trade marks is the exchange of position of B: *Performing Operations etc.*, top in patents but median in

marks, with A: *Human Necessities*, median in patents and top in marks. These differences are not surprising given the need for patents relating to new process technology and the need for trade marks reflecting brand proliferation in final consumer goods.

Summary of trends in IP

The rising trends in IP reflected in patenting via the EPO and in UK trade and service marks were not mirrored in patents taken out via the UK Patent Office. All the measures of IP show differences in trends between 1986–93 and 1993-2000, with most of the increases (or amelioration of negative trends in the case of the UK patents) being concentrated in the latter period. Chemicals moved down the rank order in UKPO patents, where the number of patents published more than halved, in contrast to remaining a principal group for patents published via the EPO, where the number of Chemical patents rose by 83%.

Trade and service marks increased rapidly during the period 1993-2000. Consumer product groups were more represented in trade marks, whereas production technology was more prevalent in patents. Service marks reflected services consumed by both producers and final consumers. Despite their rapid growth, the total accumulation of service marks from 1989 to 2000 did not quite exceed the number of UK patent publications in these years; also the total accumulation of UK trade marks for goods was 2.7 times that of UK service marks. The apparent growing relative strength in UK trade marks, especially service marks, should also be seen in the context of the much larger numbers of patents designating the UK which were published via the EPO; these still just exceeded the total of all UK trade marks in these years. Nevertheless as we have demonstrated the majority of these patents were held by non-residents of the UK.

Intellectual property in selected UK production firms

Having established the overall nature of the IP systems, and the trends observed in the numbers of IP assets, we next analysed the patterns of intellectual property acquisition by selected UK firms. It is of particular interest to see whether the trends outlined above were common to individual firms in key production sectors. Our two panels of UK firms were constructed at different times, but in both panels the firms were mostly medium to large sized in respect of their sales and employment, being generally listed on the stock market.

The source of financial data, Company Analysis, which determined which firms might be included in the panel was initially produced by Extel Financial (1996); this was used to construct the original database for 1986-95, which could be analysed by industry using UK Standard Industrial Classification (SIC) major classes. By the time of constructing the second panel for the period 1996-2000, referred to as the extended database, this source of financial data had been taken over by Thomson (2001) and a key variable of interest, the SIC industry, had changed to being reported as the US SIC class. In the original database most firms were ultimate parents but some firms had either British or foreign parents; however they all reported their accounts in Britain and the vast majority had at least one subsidiary or associate, with most having large numbers. In the extended database we focused (for this analysis by sector) on firms which were ultimate UK parents, with subsidiaries and associates in the UK or abroad. Because of these statistical differences, in Tables 5 to 7 statistics reflecting the original database are given in the ‘a’ sections of the Tables, while the extended database is reported in Tables with ‘b’ denominations.

The counts of IP assets for these panels of firms were generated by a complex process of search and matching of company names from the various sources of IP records in order to account for the complex structures of large firms and the possibility that IP assets could be registered under a variety of names (See Appendix - Technical Notes).¹ Counts in the original database used ownership patterns from “Who Owns Whom” reflecting firm structure in 1994, (Dun and Bradstreet International, 1994) while those for the extended database used patterns of firm ownership in 2001 (Dun and Bradstreet International, 2001). For UK patents and trade marks, the search was made over all the IP records for the names of the parent and all its subsidiary and associate firms which were wholly or partly owned. However it was not necessary for a firm to have a positive count in any IP dimension to be included in these panels.

When we constructed counts for the original database (1986-95) we restricted interest in EPO patent publications, for which the UK was a designated state, to those which had at least one British applicant/assignee. This restricted search would have missed patent filings by non-British subsidiaries where these had not filed jointly with a British applicant. For 1996-2000 counts were obtained on this basis for comparison, but were also made without this

¹ We initially hoped to examine a panel of firms with no subsidiaries and associates but the numbers of such firms identified were too small to merit separate analysis – see Appendix, especially Table A9.

restriction, to allow for filings by foreign subsidiaries (sole or joint with non-British firms and individuals) and to permit us to check on the effect of the earlier restriction.

Trends for a fixed panel of firms for 1986-95

In Table 5a the UKPO patent publications per firm and year relating to nearly 700 UK firms are reported by principal SIC industry sector for 1986-95. This panel contains British firms which were ultimate parents and some British subsidiaries of either foreign or other British firms. We saw above in the aggregate statistics the dramatic decline in patenting via the UKPO register and the switch into patenting via the EPO, particularly by foreign firms. Here we see that the mean rate of patenting via the UKPO by the panel of UK firms declined even more sharply than did the totals for all applicants. The most active sectors were *Aerospace & Shipping etc*, *Chemicals* and *Motor Vehicle Manufacture*; of these leading innovative sectors, in two (*Aerospace & Shipping* and *Chemicals*) the rates of patenting fell in line with the total by around 40% whereas *Motor Vehicles* increased about 10%. Three other sectors responsible for a large amount of patenting, *Electrical/Electronic*, *Extraction-Oil & Gas* and *Mechanical Engineering*, experienced dramatic declines in rates.

Table 6a documents EPO patents designating the UK. This reveals a very modest level of patenting via Europe which reached a peak around 1989-90. The possibility that these British firms were switching to the EPO route for coverage in the UK is thus not strongly supported by these data, (although the firms might have been using foreign subsidiaries not incorporated in the UK to register patents via the EPO, which would not have been picked up by our data search procedures for this period – see Appendix – Technical Notes).

In an earlier study (Greenhalgh, Longland and Bosworth, 2001a) we also checked on the average patents awarded in the US during the period 1986-95. While these rose slightly per firm (Greenhalgh, Longland and Bosworth, 2001a, Table 10) with strong performances by *Aerospace & Shipping etc.*, and *Extraction-Oil & Gas*, this rise occurred during the late 1980s and early 1990s with a decline during the mid-1990s. However there is some relief in that *Chemicals* showed a good rise and *Aerospace & Shipping* and *Motor Vehicle Manufacture* managed a small gain over the period. Despite these gains the total number of patents per firm by all three routes was still showing a fall, as the gains via the US were not enough to offset the net fall via the UK and Europe. Thus the sharp decline in overall

patenting appears to be a genuine feature of the behaviour of leading British firms from the mid 1980s to mid 1990s.

Do trade marks tell a different story? Using Table 7a, the number of marks is on average rising, but with considerable fluctuation and some falls before 1994. In most years the number of applications for trade marks is just below or roughly equal to the total of patents published via the UK and EPO routes for these firms, but by 1994 trade marks are rising faster, thus mirroring the change in the overall trends in these types of protection. Both historically and more recently, three SIC groups stand out as having made considerable use of the trade mark system: before 1986 *Chemical & Allied Products* and *Food Manufacturing* were the two leaders with twice as many trade marks as the next most active group, *Brewing, Wines & Spirits*; although this differential narrowed during the main ten year data period. Noting that the sample of firms here does not include those specialising in services, the most active production firms in respect of trade mark applications per firm during 1986-95 were in *Brewing, Wines & Spirits* and *Food Manufacturing*. *Chemical & Allied Products* was beaten into third place with a volatile performance and before 1994 some decline in annual rates. Both the food and drinks sectors were classified as low technology by the Department of Trade and Industry (1994); these are also sectors characterised by intense competition between opposing oligopolies of goods producers and powerful retail distributors within the UK.

The same government report notes the narrow base of concentration of UK R&D into Chemicals and some types of Electrical Equipment and also notes the under-representation of British production and R&D in several areas of fairly active middle-level technology. Looking at EPO patenting activity by principal product group (Table 6a), there was no sustained rise for *Aerospace & Shipping*, *Chemical & Allied Products* or for *Electrical/Electronic*. The most active firms were those in *Motor Vehicle Manufacture*, *Aerospace & Shipping etc.*, and *Chemical & Allied Products*, which are all subject to intense competition via trade within Europe and from other suppliers in the US and Japan. *Food Manufacturing* firms were also increasingly active via the EPO, much more so than via the UKPO (Table 5a); however after further investigation this proved to be due to the dominant influence of one large firm, which has a broad product range in food and other household goods.

Trends for a fixed panel of firms 1996-2000

As noted, our second panel relates only to ultimate British parent firms. Both UK patents (Table 5b) and EPO (des. UK) patents (Table 6b) show no dramatic resurgence after the earlier loss of performance in acquiring these assets: the rates of acquisition of both assets are low and stable and there are no discernable reversals of the earlier negative trends. While Table 5b thus mirrors the picture from Figure 1 (and Table 1) for the aggregate UK patenting rates, Table 6b suggests that British firms were failing to keep abreast of the rising rate of patenting activity via the EPO at this time illustrated above in Figure 2/Table 2. Higher counts for EPO patents were obtained when searches were made over all EPO patents including those without any British applicants (see Appendix Table A5) indicating that foreign subsidiaries of British firms were important conduits for acquiring new IP assets; nevertheless there were no strong upward trends here either.

In contrast, trade mark applications by this panel of British firms rose very strongly, with the average number of marks sought per firm reaching twice that seen in the earlier period. Strong showings were again made by firms in *Food & Kindred Products* and in *Chemical & Allied Products* but here we also see rapidly rising applications for trade marks in the *Printing & Publishing* sector and a high average level in the *Electric Gas & Sanitary* sector. In broad terms, lower rates of applications for trade marks are seen in sectors supplying intermediate goods to other firms and higher rates are seen in sectors with final products for sale to consumers, confirming the perceived role of brand names and product novelty in securing market share.

Questions raised by this evidence

What could have caused the fall in patenting by the British firms from 1986 to 1995 and the lack of a revival from 1996 to 2000? First there had already been considerable restructuring of industry in the early 1980s due to a high bankruptcy rate in the severe recession. Oulton (1987) has argued this killed off ambitious, financially extended firms with high debt ratios, which were potentially productive in the long run. Second there was a considerable opportunity to revise business practices as the negotiating power of trade unions was winched down by successive pieces of legislation (Blanchflower and Freeman, 1994). Both these

factors may have diverted firms from product and process development, but what happened to R&D spending?

During the late 1980s the UK was the only country in the Group of 5 to experience no increase in resources devoted to R&D as a proportion of GDP and to show very little absolute rise in real spending. In the same period the growth in real expenditure on R&D was running ahead of GDP growth in the other four countries (France, Germany, Japan, and the USA), so in these countries both absolute spending and the share of GDP devoted to R&D were rising. During the early 1990s the four partner countries sustained R&D shares of GDP in the range of 2.3% to 2.8% while the UK ratio fell below 2%. In the second half of the decade this gap persisted, with the US and Japan staying at around 2.7% and the UK reaching only 1.85% by the year 2000. The fall in UK R&D intensity followed from a rapid reduction in government outlays on R&D, particularly in defence-related research and technology support for business, and the inability of private business to make up the gap despite a rise in business R&D, (Department of Trade and Industry, 1994; Stoneman, 1999).

To explore this issue we examined the R&D records of the two panels of firms. For much of the period, separate accounting of R&D expenses was not standard practice in the UK; in general larger firms were more likely to report R&D than smaller firms (Greenhalgh et al., 2001b). A fairly small number of panel firms were reporting separate R&D accounts in all years. For the original database the ratios of R&D to sales varied somewhat but not dramatically across the sample. In the extended database we found that the distribution of R&D across firms was now much more variable, with a number of extreme observations in several sectors where R&D was a large multiple of sales. These firms were engaged in new activities such as engineering new medicines using biochemistry and genetics, or launching complex medical instruments. To calculate the average of firm R&D to sales ratios in this context produced meaningless figures dominated by these outliers. Tables 8a and 8b thus reflect the ratio of total R&D to total sales for the industry as a group, in which any extreme values for start-up firms are given their appropriate small weight.

Table 8a shows that the R&D intensity of firm sales barely changed on average from 1989-95, rising slightly during economic recession reflecting the known stability of R&D spending and for most sectors remaining higher into the economic upturn. There were persistent and unsurprising differentials by sector, with the highest ratio in *Chemicals* followed by the

Electrical & Electronic sector but a below average R&D intensity in most of the reporting sectors, including *Food Manufacturing* but also rather surprisingly *Mechanical Engineering*.

In Table 8b these ratios again show considerable cross-sector variation but, with growing R&D spending in both *Transport Equipment* and *Instruments & Related Products*, these two sectors now exceeded the R&D intensity of *Chemicals & Allied Products*; nevertheless, over the five year period in absolute terms R&D in *Chemicals & Allied Products* was still larger than the aggregate of spending in these other two sectors. By contrast the *Electronic & Other Electric Equipment* sector was not far above the average for all sectors although rising for these sampled firms. While *Food & Kindred Products* remained below average for R&D intensity, the large scale of the firms reporting (particularly of the dominant firm noted above) means that total expenditure on R&D in this sector was larger than that of both *Industrial Machinery & Equipment* and *Instruments & Related Products* over the five year period. These results suggest that both scale and intensity matter for identifying the technology hot spots of the economy; also within a fairly short time can vary and a given sector can move from being dominated by mature technology and products to developing and testing a spate of novel products using recent scientific innovation, or vice versa.

The reasons for the initial fall in patenting by large companies observed above remain to be investigated fully, but it seems possible that the costs of scientific innovation were rising and some British firms gave up trying to run with the leaders. At the same time, the beginnings of the rise in trade marks suggests that inter-firm competition may have been switching from basic product and process improvements derived from new technology into new brands based on existing technology, i.e. from competing on product quality ladders to competing via brand proliferation to use the terms coined by Grossman and Helpman (1991). Two other possible factors which might bear investigation are the increased patenting by university science departments, possibly leaving less room for business patenting, and the contracting out of R&D by large firms to smaller specialist firms using knowledge sharing agreements or licensing.

The relationship between patent and trade mark activity in firms

We have seen above that there are industry differences in the use of patents and trade marks but we also wanted to examine how similar or different are the most active firms in each category of IP. Tables 9a-c and 10a-c show the cross-tabulations of firms according to their

total performance in respect of each measure of IP over the five year periods of 1990 to 1994 (Table 9) and 1996 to 2000 (Table 10). (Appendix Tables A6a,b, show the parallel results to Tables 10a,c, using the broader count of EPO patents.) These tables were constructed with the marginal distributions divided into three groups of firms: those with none of the IP asset, those with some assets but in the lower half of the active firms, and those at or above the median of all active firms for that IP asset.

The marginal distributions re-parameterise the trends already seen above; they show that a much greater proportion of firms had no patents in the later period than in the earlier period. In contrast those with no trade marks formed a roughly constant proportion of the sample in each period, but the median number of trade marks for active firms rose sharply from 8 to 11.

The extent to which the same firms are represented in the inactive, low activity and high activity classes is tested by the computation of a Pearson Chi-square statistic for each cross tabulation; this compares the number present in a given cell with the number predicted by drawing at random from the two marginal distributions assuming independence. These statistics all strongly reject the null hypothesis of independence between the distributions. Examination of the Tables shows that firms which are low (or high) on one axis are more likely to be low (or high) on the other in these tables.

Given this rejection of independence, it is not surprising that the off-diagonal elements of the tables are small, but there are also asymmetries, for example as seen in Table 9c, where more firms are likely to have some trade marks but no EPO patents than to have some patents and no trade marks. Even more striking (Tables 9a and 10a) is the fact that 42% of our sample firms in the earlier period, and 53% in the later period, had achieved no patent publications with UK coverage within five years (and even with the broader count of EPO patents in Table A6a, the later figure is still as high as 51%). In contrast, more than two thirds of firms had made trade mark applications in each five year period. This raises the further issue of what characteristics of firms are associated with high propensities to acquire IP assets and we now turn to the examination of IP by firm size.

Innovation, market structure and firm size

According to Schumpeter (1942), the entrepreneur's role is to spot new opportunities for profit and then to obtain that profit by being first in the field, acting as a temporary

monopolist. While any successful new product or method of production calls forth imitation, so that ultimately excess profit will be eroded, innovation is more likely where profits can finance R&D, investment and new product launch. This description of competition through 'creative destruction' highlights a basic incompatibility between maintaining permanently atomistic competition and engaging in modern entrepreneurial activity. The dynamic efficiency gains from product competition between imperfectly competitive producers have to be set against the static welfare losses of market leadership (prices exceeding marginal costs and existence of excess profits), leading to a more favourable view of imperfectly competitive market structures than would arise from looking only at static efficiency conditions.

Following this Schumpeterian line of argument, due to the simultaneous need for profit incentives, ability to take risks and ability to finance R&D, there is likely to be a positive relationship between innovation, firm size and market power. Some degree of market power will guarantee profits without immediate entry and imitation. Reinvestment of excess profits together with the advantages of scale in investment in risky R&D (all eggs are not in one research basket) permits commercially viable innovation by larger firms. Equally the large diversified firm is better able to reap the benefits of invention regardless of where in its product range the innovations occur. Elements of indivisibility in cost-reducing process innovations will also make them more profitable for larger firms.

In contrast, Arrow (1962) showed that the prospect of gaining a temporary monopoly via patent rights can offer a greater incentive to invent to producers in a competitive market than to a monopolist, who already enjoys high profits and has less to gain from further monopoly power. Although this is technically correct for a single cost-reducing invention, it has little to say about the market dynamics of product innovation. How will the atomistic firm finance the risky R&D before it can obtain the monopoly patent? How will a sluggish monopoly producer maintain market dominance in the medium run in the absence of any product innovation, particularly when there are further potential new entrants via international trade? But there are also difficulties with the Schumpeterian tradition; if we accept that some product market concentration is necessary, then theory offers few precise recommendations about how much market power is enough. Should we assume that industries with slow rates of innovation must have become sclerotic due to market concentration and are in need of an injection of competition?

Authors like Freeman et al. (1982) have argued strongly, following Schumpeter (1939) on the theory of long cycles, that across industries there will be sizeable differences in the rate of technological opportunity, as the pace of scientific advance conditions the progress of its commercial application via new processes and products. Additionally the evolution of patterns of demand play a role in what are the hot technology sectors: marketing staff identify the product needs of final consumers as their lifestyles evolve; also changing inter-industry relationships can exert a strong pull effect on innovation as growth sectors will need to invest and replace equipment faster than declining sectors.

Empirical analysts have investigated the issue of firm size and innovation in two steps: Is there evidence that R&D spending increases more than proportionately with firm size? Does a unit of R&D spending result in more innovation if spent in a large or a small firm? Most of the empirical evidence relates to the US and it shows that R&D increases broadly in proportion to firm size or slightly faster, but that patents increase less than proportionately to R&D spending (Acs and Audretsch, 1991). This raises further questions in that large firms may choose to patent less frequently than smaller firms. However innovation survey data for the US in the mid-1970s (Acs and Audretsch, 1991) confirms the view that the productivity of R&D conducted in small firms was higher, or equivalently there appear to be decreasing returns to scale in R&D, in direct contrast to the Schumpeterian hypothesis.

Earlier evidence for the UK also raises doubts about the wisdom of relying on large firms to generate technological change. Pavitt et al. (1987) show that the relationship between innovation and firm size before 1983 was non-linear, being higher for small and large firms but lower for medium-sized companies and the best scale for innovation was declining through the period 1956 to 1983. Pavitt et al. (1988) find that the size of innovating divisions within large firms has steadily decreased in the post-war period, even though firm size was increasing, suggesting that firms were themselves aware of the merits of small scale for innovation.

The scale of operations may have an impact on the possibility of funding R&D from internal sources via retained earnings. Hall (1992) presents detailed empirical analysis of the elasticity of R&D investment with respect to cash flow, which is unambiguously positive in a large panel of US firms. Further, she shows that debt leverage ratios are strongly negatively correlated with R&D investment, confirming that the risks associated with R&D render it an unsuitable activity for debt finance. Earlier analysis by Schott (1978) for the British

manufacturing sector also showed that financial factors played an important role in determining R&D spending. For these reasons there is still some mileage in the view that large scale matters for R&D and innovation.

However a multivariate study of the propensity to innovate again using data ending around 1983 (Blundell et al., 1995) shows that, while a rise in the firm's own market share is a positive inducement to innovate, the higher the industry concentration ratio the lower is the propensity to innovate. The net impact of increasing concentration is thus to reduce the rate of innovation so they conclude 'The anti-trust authorities should remain wary of arguments that monopoly power is the price of a dynamically efficient economy.'

Intellectual property by firm size – empirical analysis

In order to investigate the relation between the size of the firm and acquisition of IP assets, we ordered the firms by rank order of sales. Taking the smallest first, the cumulative proportion of IP (y-axis) was then plotted against the cumulative proportion of total value of sales (x-axis). If each firm gained IP at the same rate as its contribution to gross output then the two measures would also rise at the same rate, to give a straight line with a slope of 45 degrees. If the plot lies above (below) the 45° line then smaller firms are obtaining proportionately more (less) new IP assets within the period.

In each of Figures 5–7 the plots 'a' and 'b' relate to 1995 and 2000 respectively; in both years the economy was enjoying sustained growth at around 3% p.a. and falling unemployment, so these data are not affected by recent cyclical fluctuations in either sales or rates of new product launch. The density of observation points gives a key to how many firms are represented in each part of the sales and IP distributions. The density of observations is very skewed and clearly at the top end of each of the curves in Figures 5 to 7 there is a 'super-league' of large firms which contributed a very large share of sales.²

Figure 5 records the size distribution of UK patent publications: for each date the curve is firmly above the line of equality indicating that 'small(er) is beautiful' in the publication of British patents (note that few of the firms in this sample would qualify as SMEs under common definitions). In 1995 a super-league of the largest 15 firms contributed almost half

² The super-league firms differ between the 1995 and 2000.

of sales (gross output) within this sample, but only around 27% of UK patents; by 2000 the top 15 were achieving 56% of sales but publishing 13% of new UK patents (similarly shaped curves were obtained for 1985 and 1990; see Greenhalgh et al., 2001a).

The picture for EPO patent publications (designating the UK) in Figure 6a is rather different: in 1995 smaller firms are not able to keep up with larger firms, so the curve initially dips below the 45° line. Mid-range firms were most energetic in EPO patenting and the super-league patented proportionately to their total sales. By 2000 (Figure 6b) it is the smallest firms rather than the medium sized firms which were contributing more strongly, but some bigger firms within the super-league were also patenting to a higher extent than proportionately (see also the Appendix, Figure A1, for the wider EPO patent measure, including counts of publications by foreign subsidiaries). In effect the size distribution breaks naturally into two subgroups, of super-league and other firms, as the 15th largest firm is very close to the line of equality at both dates (this was also true in 1986 and 1990 – see Greenhalgh et al., 2001a).

Given that patenting via the EPO is comparatively more expensive if coverage is required in a small number of countries, but cheaper for broad coverage, it is not surprising to find the smallest firms patenting least frequently by this route in 1995 if they were aiming to reach a limited number of export destinations. However the patterns observed for 2000 suggest that such costs are not the only driver, as the greater effort by smaller firms within each size range could be interpreted as using EPO patenting as a strategy to gain market share.

Trade marks applications (Figure 7) are distributed more similarly to UK patents than to EPO patents, showing inequality of effort in favour of smaller firms at both dates. In 1995 the super-league top 15 were applying for only 33% of new trade marks, slightly above their share of UK patenting rates. By 2000 the largest firms were applying more vigorously for trade marks than in 1995, so the super-league's share of new trade marks had grown to 36% of UK trade mark applications. Thus while patenting via the UK by these firms was declining and EPO patenting was remaining proportional to sales, applications for registered trade marks were increasing along with sales in the super-league.

There are other ways to rank firms in terms of size – an obvious alternative is by employment rather than sales. In Tables 11a,b, we have calculated the rate of IP asset acquisition per 1000

employees in order to compare performance, tabulating various years to examine the stability of the patterns (see also Table A7 for the figures for the alternative EPO patent measure). Over time many firms have reduced their labour intensity as they adopted more cost effective modes of production, but also firms which increased sales may have expanded their employment. We have investigated the econometric relationship between IP and employment in another paper (Greenhalgh et al., 2001b), which showed that acquiring IP assets was generally associated with added employment at the margin, *ceteris paribus* on sales and other factor costs.

Here we find that Tables 11a,b, confirm the non-linearity of rates of IP acquisition by firm size for UK and EPO patents. In the original database, firms employing less than 100 workers are ranked first or second by rates of patenting per worker in five out of six observations, the exception being UK patents in the 1990 recession, but in that same year the same firms' patent publications via the EPO were very high. These small firms, together with firms employing less than 200, are also star performers in the acquisition of trade marks in all years. The extended database (Table 11b) confirms these relative performances even more strongly showing the rates of acquisition of IP per worker to be highest in smaller enterprises and emphasising that whether we measure firm size by employment or by sales, as in Figures 5 to 7 above, the highest intensities are generally the preserve of the smaller firms.³ These findings do not support the view that IP assets are unlikely to be applied for by small firms as they face more costs than larger firms with specialist managers of IP assets.

Among medium and large sized firms employing at least 200 workers there is considerable variation in IP rates per worker from year to year and between types of IP, but it is difficult to discern any strong general patterns or trends beyond those already identified of increasing trade marks and declining patent activity. Pavitt et al. (1987) showed that rates of innovation (from survey data) in the period 1956 to 1983 were generally highest in the largest firms 50,000+; but the innovation rates of small firms 100-199 and of firms with 200-499 workers were rising fast in the post war era. Our results could only be compatible with theirs if the patenting rates of the very largest firms per innovation obtained were very much lower than for smaller firms. It seems rather more likely that the trends they identified before 1983 have

³ The sole exception is in the acquisition of US patent grants analysed in the original database – see Greenhalgh et al. (2001a), Figures 10a-c, and Table 14, where there was little variation across firm size.

continued, with ever smaller firms making the running in introducing new technology and design to the market.

As we have demonstrated using econometric analysis of a fixed panel of firms (Greenhalgh and Longland, 2002), the increase in the level of net output of firms is not driven by the absolute levels of new IP assets per firm, but by IP intensity, namely the ratio of new IP assets to firm size (measured by employment). From this evidence, the prediction is thus that the most IP intensive small firms will grow and less IP intensive firms will shrink. The observed increased share of sales for the super-league firms recorded here is unlikely to be purely driven by in-house product innovations reflected in their increasing share of UK trade marks. More likely it also derives from the expansion of the firm through mergers and acquisitions, greater out-sourcing in order to supply more stages in the product supply chain, and economies of scale in advertising and delivery. Some of these trends are themselves being driven by innovations in communications and transport, arising from the diffusion of generally available new technologies, rather than being the result of in-house R&D.

Conclusions

This study has contrasted the strong positive trends in EPO patent publications with a strongly contrary trend in British patent publications. In total the ownership of IP rights with coverage in Britain still rose, as the fall in patenting via the UK Patent Office was more than compensated by a shift to applications made directly via the European Patent Office. Nevertheless there was a significant decline in the share of patents held by UK residents and an even more dramatic decline in the total number of patents with coverage in the UK held by a selected panel of surviving large British firms in the period 1986-95. These trends levelled out in the mid-1990s and there were no dramatic reversals thereafter.

This fall in UK-owned IP protection includes technology fields involved in product areas which have historically been important to the production of high technology goods in Britain. The decline is consistent with the decline of British manufacturing in general and with the UK's ever greater reliance on the input of investment and technology transfer from foreign owned firms.

Domestic performance appeared relatively stronger in trade marks. Applications via the UK rose rapidly in the second half of the 1990s and the level and trends in applications for goods

and service marks for the UK were similar to those seen in other jurisdictions. However UK firms appeared to experience a recession-induced lag behind competitors in the early 1990's. These findings raise serious questions about the costs in terms of lower rates of innovation of the rapid structural adjustment in the 1980s, of the severe recession in the early 1990s, and of the reduction of government funding for business R&D over the same period. They also suggest that firms saw higher rates of return in increasing product variety backed by trade marks than in major product improvements protected by patents.

Evidence on the relationship between IP acquisition and firm size, whether measured by sales or by employment, generally showed a higher propensity for both UK patent and UK trade mark acquisition by smaller firms. Given the very high concentration ratios demonstrated in our data, this raises important questions for the new UK Competition Commission, concerning whether large firms become less innovation active as they expand their market shares and, if so, how this should guide the framing of policy relating to company mergers and acquisitions. The Patent Office has in recent years restructured fees to reduce patent and trade mark application fees and this should continue to encourage the formal protection of IP especially by small firms.

Since 2000 the UK has introduced an R&D tax credit, initially directed at small research-intensive firms, but extended in 2001 to all firms regardless of size, which will obviously help to reduce the cost of R&D to firms. However given that the tax credit applies to total R&D spending, rather than to the marginal increase in R&D as in several other countries (Griffith et al., 1995; Hall, 1993) it may be expected to have less impact per pound of public expenditure than would a marginal subsidy. Even so, the rate of development of significantly novel innovations protected by patents may not rise if firms persist in the strategy of increasing product variety protected by trade marks, as evidenced in this study.

Further study is needed into the total social returns to different types of innovation by firms, comparing novel innovation protected by patents with brand proliferation protected by trade marks and to explore not only the gains to firms but also to their customers and industry counterparts. If the social returns to novel innovation are much larger, then Britain may gain little from the emphasis on brand proliferation by its domestic firms. A move to reshape the R&D tax credit to support firms which are both expanding their R&D and their level of patenting, thus raising novel product or process innovation rates, might then be appropriate to

achieve the maximum improvement in British productivity and competitiveness in the longer term.

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Table 1: UKPO patent publications by year of publication, by International Patent Classification

Section	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1986-2000
A - Human Necessities	2319	2429	2279	2272	2056	1911	1865	1733	1803	1888	1925	2006	2097	1993	2048	30624
B - Performing Operations etc.	4193	3925	3619	3530	3299	3142	2986	2912	2876	2928	2998	3079	2924	2894	2966	48271
C - Chemistry; Metallurgy	1986	1783	1513	1301	1133	1019	1022	876	921	985	934	995	978	882	885	17213
D - Textiles; Paper	418	414	362	330	261	255	217	189	195	240	209	222	214	173	135	3834
E - Fixed Constructions	1229	1161	1135	1111	1078	1058	1004	1079	1130	1128	1131	1137	1101	1192	1232	16906
F - Mech. Engineering etc.	2746	2476	2384	2236	2094	1987	1955	1670	1770	1692	1794	1905	1792	1690	1712	29903
G - Physics	2576	2809	2465	2585	2457	2391	2334	2089	2188	2096	2249	2636	2633	2533	2903	36944
H - Electricity	2301	2275	2037	2106	1960	2023	2078	1975	1929	2076	2202	2637	2801	2766	2800	33966
Sum of A-H	17768	17272	15794	15471	14338	13786	13461	12523	12812	13033	13442	14617	14540	14123	14681	217661
Publications	15883	15372	14067	13765	12695	12178	11794	10980	11104	11142	11451	12474	12287	12042	12516	189750
Sections per Publication	1.12	1.12	1.12	1.12	1.13	1.13	1.14	1.14	1.15	1.17	1.17	1.17	1.18	1.17	1.17	1.15

Table 2: EPO patent publications by year of publication, by International Patent Classification

Section	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1986-2000
A - Human Necessities	7288	7984	8739	9273	9988	9880	10055	10090	10340	11358	11655	12766	13803	15590	20019	168828
B - Performing Operations etc.	9644	10396	11156	12195	13209	13568	13662	13068	13228	13758	14212	14899	16804	18378	20763	208940
C - Chemistry; Metallurgy	10832	11003	12144	13340	13992	13983	13463	13292	12345	13353	13678	14188	15511	16224	19851	207199
D - Textiles; Paper	1106	1171	1408	1598	1695	1705	1695	1542	1503	1581	1538	1588	1814	2064	2097	24105
E - Fixed Constructions	1790	1864	1917	2046	2359	2346	2247	2148	2318	2520	2494	2408	3024	3207	3631	36319
F - Mech. Engineering etc.	4716	4856	4921	5332	5729	5883	6036	5603	5601	6024	6309	6708	7840	8609	9380	93547
G - Physics	8376	8922	9547	10627	12225	13072	13138	12340	12116	11970	12864	13413	15541	16268	20370	190789
H - Electricity	6894	7101	7610	8354	9439	10376	10672	10116	10210	10841	11748	12565	15429	16990	20892	169237
Sum of A-H	50646	53297	57442	62765	68636	70813	70968	68199	67661	71405	74498	78535	89766	97330	117003	1098964
Publications	41123	43292	46672	51262	56334	58159	57952	55360	54963	57848	61028	64139	73323	79764	95976	897195
Publications designating UK	38160	40139	43450	47670	52614	54488	53999	51332	50672	53395	56288	58914	65446	71008	88290	825865
Sections per Publication	1.23	1.23	1.23	1.22	1.22	1.22	1.22	1.23	1.23	1.23	1.22	1.22	1.22	1.22	1.22	1.22

Table 3: UK trade mark applications by year of application, by goods mark classes 1 - 34, aggregated to mirror IPC sections

Class	Pre-1989	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1989-2000
A - Human Necessities	140422	13941	13990	12092	12654	11848	14795	18956	17403	20729	22337	22073	23303	204121
B - Performing Operations etc.	34143	3910	4166	3470	3421	3384	4566	6064	5863	7083	7676	8006	9495	67104
C - Chemistry; Metallurgy	68290	5016	5057	4393	4578	4108	5508	7013	6559	8160	8530	8801	9387	77110
D - Textiles; Paper	14504	1241	1093	919	910	723	1100	1371	1446	1974	2255	2194	2341	17567
E - Fixed Constructions	8476	826	788	650	618	568	669	883	791	941	991	1084	1232	10041
F - Mech. Engineering etc.	29528	2353	2404	1969	1959	1814	2277	2805	2628	2762	3044	3131	3375	30521
G+H - Physics & Electricity	40370	5216	5798	5060	5317	5211	6834	8724	7875	9427	9554	10501	13423	92940
Sum of A-H	335733	32503	33296	28553	29457	27656	35749	45816	42565	51076	54387	55790	62556	499404

Table 4: UK service mark applications by year of application, by service mark classes 35 - 42

Class	Pre-1989	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1989-2000
35 - Advertising and Business	3052	1054	1132	872	911	859	1352	2131	2354	3355	3595	4808	8804	31227
36 - Insurance and Financial	3695	1030	1063	936	847	860	1448	1861	1910	2579	2748	3391	4931	23604
37 - Construction and Repair	2353	794	726	595	596	514	729	1155	1233	1561	1534	1853	2489	13779
38 - Communication	1162	406	429	408	433	445	711	1136	1400	1720	1996	2854	5275	17213
39 - Transportation and Storage	2317	666	557	542	543	600	833	1029	1186	1379	1591	1760	2401	13087
40 - Material Treatment	494	179	193	161	172	175	214	328	413	450	555	550	655	4045
41 - Education and Entertainment	2292	1068	1116	1012	951	977	1457	2589	3055	4063	4422	5201	7479	33390
42 - Miscellaneous Services	5496	1881	1922	1744	1523	1613	2246	3820	4215	5533	6305	7690	11230	49722
Sum of 35-42	20861	7078	7138	6270	5976	6043	8990	14049	15766	20640	22746	28107	43264	186067

Table 5a: Production firms - Mean numbers of UKPO patent publications by year

UK SIC	Firms	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1986-95	Total 86-95
Aerospace & Shipping etc	15	27.8	34.3	31.1	32.5	27.1	28.5	25.9	21.2	20.7	15.7	26.5	3973
Brewing Wines & Spirits	27	0.9	1.6	1.0	1.0	0.8	1.0	1.1	1.0	1.6	1.6	1.2	314
Building & Construction	56	1.4	1.6	1.3	1.2	0.9	0.9	0.8	0.9	0.6	0.5	1.0	558
Chemicals	56	8.0	8.0	7.0	6.3	4.5	4.4	4.2	4.2	4.9	4.6	5.6	3132
Electrical & Electronic	66	3.6	3.8	3.2	2.3	2.2	2.0	1.2	1.1	1.1	1.1	2.2	1423
Extraction-Oil & Gas	21	6.5	8.0	8.5	5.2	5.5	4.8	4.9	4.1	2.1	2.5	5.2	1094
Food Manufacturing	42	2.0	2.7	1.8	1.7	2.2	1.7	1.7	1.4	1.6	1.9	1.9	786
Mechanical Engineering	55	3.0	2.8	2.3	2.3	1.7	1.9	2.2	2.0	1.7	1.4	2.1	1176
Motor Vehicle Manufctr	18	8.8	7.6	9.9	9.5	6.7	7.7	9.5	7.1	11.7	9.7	8.8	1589
Other Metals Manufacture	27	2.4	2.8	3.3	2.1	3.2	2.9	1.9	2.7	2.0	2.1	2.5	684
Printing Publishing & Paper	30	2.2	1.5	1.4	1.3	1.3	1.2	1.0	1.1	1.1	2.3	1.5	435
Rubber & Plastic	32	2.5	3.0	2.8	2.3	2.5	2.6	2.1	2.3	2.8	2.4	2.5	812
Textiles	31	0.5	0.4	0.4	0.3	0.3	0.2	0.3	0.3	0.1	0.2	0.3	90
All	694	3.6	3.9	3.6	3.3	2.8	2.8	2.7	2.4	2.5	2.3	3.0	20697

Table 5b: Production firms - Mean numbers of UKPO patent publications by year

US SIC	Firms	1996	1997	1998	1999	2000	1996-2000	Total 96-00
15 General Building Contractors	35	0.0	0.0	0.1	0.2	0.2	0.1	18
20 Food & Kindred Products	35	0.7	0.5	0.9	0.4	0.7	0.6	112
27 Printing & Publishing	24	0.0	0.2	0.1	0.1	0.0	0.1	9
28 Chemicals & Allied Products	37	1.7	2.5	2.1	2.4	1.4	2.0	371
32 Stone, Clay & Glass Products	19	0.4	0.6	1.3	1.0	0.4	0.7	71
34 Fabricated Metal Products	20	1.5	1.0	0.5	0.6	0.3	0.8	78
35 Industrial Machinery & Equipment	34	2.4	1.9	2.1	2.0	2.1	2.1	356
36 Electronic & Other Electric Equip.	33	0.9	1.6	1.1	0.9	1.9	1.3	211
37 Transport Equipment	27	2.3	2.9	3.6	3.1	2.0	2.8	374
38 Instruments & Related Products	32	1.3	1.1	1.2	1.6	2.6	1.5	247
49 Electric, Gas & Sanitary	20	0.2	0.6	0.3	0.6	0.7	0.5	49
10-49 All production	487	0.9	1.0	1.0	1.0	1.0	1.0	2341

**Table 6a: Production firms - Mean numbers of EPO (designating the UK) patent publications by year
(restricted to patents with at least one British applicant/assignee)**

UK SIC	Firms	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1986-95	Total 86-95
Aerospace & Shipping etc	15	4.1	5.9	6.3	5.9	9.1	8.5	4.9	4.7	5.9	5.9	6.1	920
Brewing Wines & Spirits	27	0.3	0.6	0.4	0.4	0.3	0.4	1.0	0.3	1.1	0.9	0.5	146
Building & Construction	56	0.1	0.1	0.4	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	138
Chemicals	56	4.6	4.9	5.4	5.6	5.6	4.6	4.8	5.0	4.4	4.5	4.9	2769
Electrical & Electronic	66	1.4	1.7	1.8	2.4	2.1	1.7	1.3	1.5	1.5	1.5	1.7	1117
Extraction-Oil & Gas	21	4.5	4.0	3.8	3.9	3.6	3.6	3.9	2.5	2.4	2.1	3.4	721
Food Manufacturing	42	2.6	3.0	4.2	5.4	5.2	5.7	5.4	5.4	2.0	5.0	4.4	1847
Mechanical Engineering	55	0.9	0.7	0.8	0.7	0.4	0.6	0.6	0.5	0.5	0.5	0.6	347
Motor Vehicle Manufctr	18	5.3	6.2	6.1	6.4	8.0	7.3	8.9	5.6	7.3	6.6	6.8	1220
Other Metals Manufacture	27	0.4	0.4	0.6	0.8	1.1	0.5	0.4	0.3	0.2	0.3	0.5	133
Printing Publishing & Paper	30	0.6	0.6	0.6	0.6	0.7	0.6	0.4	0.4	0.3	0.5	0.5	156
Rubber & Plastic	32	0.4	0.6	0.6	0.8	0.8	0.7	0.7	0.9	0.7	0.9	0.7	233
Textiles	31	0.1	0.0	0.1	0.0	0.4	0.0	0.0	0.0	0.1	0.2	0.1	30
All	694	1.5	1.6	1.7	1.9	1.9	1.8	1.8	1.6	1.4	1.6	1.7	11695

**Table 6b: Production firms - Mean numbers of EPO (designating the UK) patent publications by year
(restricted to patents with at least one British applicant/assignee)**

US SIC	Firms	1996	1997	1998	1999	2000	1996-2000	Total 96-00
15 General Building Contractors	35	0.0	0.1	0.1	0.1	0.0	0.0	8
20 Food & Kindred Products	35	5.5	5.5	5.0	4.9	5.3	5.2	916
27 Printing & Publishing	24	0.0	0.0	0.0	0.1	0.0	0.0	3
28 Chemicals & Allied Products	37	4.9	4.2	3.4	3.2	3.6	3.9	718
32 Stone, Clay & Glass Products	19	0.7	0.7	0.7	0.5	0.7	0.7	63
34 Fabricated Metal Products	20	0.3	0.1	0.2	0.2	0.1	0.2	15
35 Industrial Machinery & Equipment	34	0.9	1.3	1.3	2.4	2.4	1.7	282
36 Electronic & Other Electric Equip.	33	0.5	0.8	1.0	1.0	1.7	1.0	164
37 Transport Equipment	27	1.0	0.8	1.6	1.1	1.1	1.1	153
38 Instruments & Related Products	32	1.8	1.7	1.7	1.8	2.7	1.9	309
49 Electric, Gas & Sanitary	20	0.1	0.2	0.4	0.3	0.5	0.3	28
10-49 All production	487	1.4	1.3	1.4	1.4	1.6	1.4	3468

Table 7a: Production firms - Mean numbers of UK trade mark applications (Classes 1-42) by year

UK SIC	Firms	Pre-86	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1986-95	Total 86-95
Aerospace & Shipping etc	15	1312	7.8	5.8	5.1	6.3	8.0	5.1	6.1	8.8	3.5	10.2	6.7	998
Brewing Wines & Spirits	27	4580	23.8	8.5	11.6	11.8	10.6	10.6	8.4	8.6	16.2	27.0	13.7	3703
Building & Construction	56	801	2.0	1.6	2.1	1.2	1.4	0.6	1.0	0.9	0.6	1.5	1.3	715
Chemicals	56	10541	11.5	9.4	13.5	9.5	9.6	9.1	9.8	6.8	9.2	11.9	10.0	5614
Electrical & Electronic	66	1676	1.7	2.0	1.2	1.6	1.4	1.2	1.2	1.0	2.0	2.0	1.5	1016
Extraction-Oil & Gas	21	2428	6.9	2.9	4.9	7.6	6.0	4.1	6.3	4.4	6.4	8.4	5.8	1216
Food Manufacturing	42	10178	12.4	8.4	11.2	13.8	13.4	11.5	13.1	10.9	16.4	16.2	12.7	5346
Mechanical Engineering	55	1418	1.1	1.3	1.2	1.4	2.5	1.9	1.2	1.1	1.1	1.9	1.5	807
Motor Vehicle Manufctr	18	1034	6.1	5.1	3.3	2.8	2.5	3.2	2.2	4.2	4.6	4.1	3.8	682
Other Metals Manufacture	27	431	1.3	0.7	1.7	1.7	0.7	1.3	1.1	1.0	1.1	1.4	1.2	326
Printing Publishing & Paper	30	530	1.6	1.0	1.8	2.0	1.8	1.8	1.0	2.0	3.0	2.2	1.8	545
Rubber & Plastic	32	1810	4.6	2.8	3.5	3.8	3.3	3.6	3.4	2.8	4.3	3.5	3.6	1143
Textiles	31	1579	2.5	1.6	1.2	1.4	1.3	1.4	1.4	0.7	1.3	1.4	1.4	439
All	694	51456	5.3	3.7	4.5	4.5	4.4	4.0	4.0	3.7	5.0	6.1	4.5	31393

Table 7b: Production firms - Mean numbers of UK trade mark applications (Classes 1-42) by year

US SIC	Firms	1996	1997	1998	1999	2000	1996-2000	Total 96-00
15 General Building Contractors	35	0.5	1.4	1.9	1.9	3.9	1.9	328
20 Food & Kindred Products	35	19.5	21.2	30.2	22.1	27.2	24.1	4209
27 Printing & Publishing	24	10.9	21.4	21.8	21.5	50.4	25.2	3023
28 Chemicals & Allied Products	37	12.2	18.3	18.8	23.8	17.3	18.1	3343
32 Stone, Clay & Glass Products	19	3.4	2.4	5.9	2.4	3.2	3.4	326
34 Fabricated Metal Products	20	0.9	1.0	1.6	3.2	1.1	1.6	156
35 Industrial Machinery & Equipment	34	2.2	2.1	2.0	2.9	3.4	2.5	427
36 Electronic & Other Electric Equip.	33	1.7	1.4	2.1	1.3	1.3	1.6	259
37 Transport Equipment	27	2.9	3.1	2.4	5.1	2.2	3.1	425
38 Instruments & Related Products	32	1.8	1.9	1.3	2.0	1.4	1.7	269
49 Electric, Gas & Sanitary	20	17.5	22.6	20.3	17.5	16.3	18.8	1882
10-49 All production	487	6.1	7.8	8.4	8.9	10.9	8.4	20494

Table 8a: Production firms with R&D accounts - Industry (and Total) R&D intensities as a percentage of sales

UK SIC	Firms*	1989	1990	1991	1992	1993	1994	1995	1989-95
Chemicals	29 (17)	5.56	5.93	6.36	6.76	6.46	6.77	6.42	6.33
Electrical & Electronic	33 (20)	2.33	2.69	2.77	2.72	2.63	2.63	3.16	2.70
Food manufacturing	9 (5)	1.19	1.24	1.31	1.34	1.36	1.36	1.38	1.32
Mechanical Engineering	21 (13)	1.26	1.21	1.27	1.39	1.29	1.09	0.98	1.20
Metal manufacture	8 (5)	0.66	0.73	0.78	0.97	1.11	0.95	0.80	0.85
Motor vehicle manufctr	8 (6)	2.56	2.65	2.30	1.78	2.66	2.14	2.28	2.34
Non metals manufacture	8 (6)	1.12	1.21	1.30	1.17	1.10	1.05	0.71	1.11
Rubber & Plastic	10 (4)	0.93	1.03	1.05	1.01	1.08	1.14	1.10	1.05
All "production"	214 (133)	1.86	1.94	1.94	2.02	1.89	1.83	1.72	1.89

*Note: When this original database was constructed some firms had not yet reported accounts for 1995. The number of firms in parentheses is the smaller number of firms with reported accounts used to construct the industry intensity for 1995.

Table 8b: Production firms with R&D accounts - Industry (and Total) R&D intensities as a percentage of sales

US SIC	Firms	1996	1997	1998	1999	2000	1996-2000
20 Food & Kindred Products	9	1.19	1.22	1.32	1.44	1.57	1.35
28 Chemicals & Allied Products	29	3.97	4.59	7.12	7.58	8.03	6.40
34 Fabricated Metal Products	8	0.77	0.81	1.04	1.08	1.14	0.96
35 Industrial Machinery & Equipment	25	3.09	2.64	2.65	3.81	3.69	3.19
36 Electronic & Other Electric Equipment	22	1.10	1.28	1.76	2.34	2.72	1.83
37 Transport Equipment	16	5.46	5.36	6.37	8.36	9.52	7.21
38 Instruments & Related Products	25	5.47	5.82	6.28	7.11	8.12	6.68
49 Electric, Gas & Sanitary	11	0.51	0.47	0.50	0.40	0.26	0.41
10-49 All production	190	1.37	1.45	2.03	2.13	1.90	1.78

Table 9a: Cross tabulation of UKPO patent publications against EPO (des. UK) patent publications involving at least one British applicant/assignee 1990-94

UKPO Publications 1990-1994	EPO (des UK) Publications with UK association 1990-1994						Total	
	None		1-3		4+		No.	%
	No.	%	No.	%	No.	%		
None	365	(42.15)	29	(3.35)	4	(0.46)	398	(45.96)
1-4	129	(14.90)	84	(9.70)	26	(3.00)	239	(27.60)
5+	27	(3.12)	74	(8.55)	128	(14.78)	229	(26.44)
Total	521	(60.16)	187	(21.59)	158	(18.24)	866	(100)

Pearson Chi² (4) = 476.53 Pr = 0.000

Table 9b: Cross tabulation of UKPO patent publications against UK trade mark applications 1990-94

UKPO Publications 1990-1994	UK TM Applications 1990-1994						Total	
	None		1-7		8+		No.	%
	No.	%	No.	%	No.	%		
None	191	(22.06)	141	(16.28)	66	(7.62)	398	(45.96)
1-4	49	(5.66)	90	(10.39)	100	(11.55)	239	(27.60)
5+	30	(3.46)	56	(6.47)	143	(16.51)	229	(26.44)
Total	270	(31.18)	287	(33.14)	309	(35.68)	866	(100)

Pearson Chi² (4) = 165.33 Pr = 0.000

Table 9c: Cross tabulation of EPO (des. UK) patent publications involving at least one British applicant/assignee against UK trade mark applications 1990-94

EPO (des UK) Publications with UK association 1990-1994	UK TM Applications 1990-1994						Total	
	None		1-7		8+		No.	%
	No.	%	No.	%	No.	%		
None	224	(25.87)	194	(22.40)	103	(11.89)	521	(60.16)
1-3	39	(4.50)	67	(7.74)	81	(9.35)	187	(21.59)
4+	7	(0.81)	26	(3.00)	125	(14.43)	158	(18.24)
Total	270	(31.18)	287	(33.14)	309	(35.68)	866	(100)

Pearson Chi² (4) = 205.85 Pr = 0.000

Table 10a: Cross tabulation of UKPO patent publications against EPO (des. UK) patent publications involving at least one British applicant/assignee 1996-2000

UKPO Publications 1996-2000	EPO (des UK) Publications with UK association 1996-2000						Total	
	None		1-4		5+		No.	%
	No.	%	No.	%	No.	%	No.	%
None	257	(52.77)	21	(4.31)	7	(1.44)	285	(58.52)
1-3	55	(11.29)	28	(5.75)	15	(3.08)	98	(20.12)
4+	19	(3.90)	29	(5.95)	56	(11.50)	104	(21.36)
Total	331	(67.97)	78	(16.02)	78	(16.02)	487	(100)

Pearson $\chi^2(4) = 218.27$ Pr = 0.000

Table 10b: Cross tabulation of UKPO patent publications against UK trade mark applications 1996-2000

UKPO Publications 1996-2000	UK TM Applications 1996-2000						Total	
	None		1-11		12+		No.	%
	No.	%	No.	%	No.	%	No.	%
None	130	(26.69)	91	(18.69)	64	(13.14)	285	(58.52)
1-3	22	(4.52)	45	(9.24)	31	(6.37)	98	(20.12)
4+	7	(1.44)	29	(5.95)	68	(13.96)	104	(21.36)
Total	159	(32.65)	165	(33.88)	163	(33.47)	487	(100)

Pearson $\chi^2(4) = 86.89$ Pr = 0.000

Table 10c: Cross tabulation of EPO (des. UK) patent publications involving at least one British applicant/assignee against UK trade mark applications 1996-2000

EPO (des UK) Publications with UK association 1996-2000	UK TM Applications 1996-2000						Total	
	None		1-11		12+		No.	%
	No.	%	No.	%	No.	%	No.	%
None	143	(29.36)	108	(22.18)	80	(16.43)	331	(67.97)
1-4	14	(2.87)	32	(6.57)	32	(6.57)	78	(16.02)
5+	2	(0.41)	25	(5.13)	51	(10.47)	78	(16.02)
Total	159	(32.65)	165	(33.88)	163	(33.47)	487	(100)

Pearson $\chi^2(4) = 73.10$ Pr = 0.000

Table 11a: Production firms 1986-95 - Mean IP measures per thousand workers by firm size

Total Employment	UKPO Patent Publications			EPO (des. UK) Patent Publications involving at least one British applicant/assignee			UK Trade Mark Applications		
	1986	1990	1995	1986	1990	1995	1986	1990	1995
< 100	1.39	0.32	3.21	0.57	4.55	1.50	14.78	3.27	6.39
100-199	1.84	0.51	0.20	0.86	0.23	0.00	5.70	4.90	3.77
200-499	1.33	0.44	0.29	0.23	0.35	0.42	2.54	1.90	1.69
500-999	1.35	0.68	0.17	0.20	0.42	0.31	1.54	1.47	2.05
1000-1999	1.28	0.56	0.45	0.35	0.29	0.22	1.51	1.23	1.24
2000-4999	1.14	0.68	0.38	0.19	0.28	0.14	0.74	0.90	1.11
5000-9999	0.87	0.50	0.52	0.29	0.19	0.18	1.41	0.79	0.82
10000-19999	0.47	0.43	0.43	0.23	0.21	0.19	1.01	0.88	1.55
20000-49999	0.39	0.25	0.37	0.15	0.12	0.35	1.02	0.60	0.73
>= 50000	0.39	0.32	0.15	0.22	0.37	0.27	0.56	0.38	1.09

Table 11b: Production firms 1996-2000 - Mean IP measures per thousand workers by firm size

Total Employment	UKPO Patent Publications			EPO (des. UK) Patent Publications involving at least one British applicant/assignee			UK Trade Mark Applications		
	1998	2000	1996-2000	1998	2000	1996-2000	1998	2000	1996-2000
< 100	6.51	5.04	4.72	5.86	4.38	6.92	145.41	33.03	67.32
100-199	1.73	1.78	1.89	1.13	5.15	2.19	14.75	6.95	13.37
200-499	0.80	0.20	0.63	1.17	0.43	0.79	5.30	4.42	4.25
500-999	0.32	1.45	0.46	0.76	0.67	0.41	1.71	5.68	2.61
1000-1999	0.27	0.30	0.30	0.39	0.91	0.46	1.85	2.80	2.01
2000-4999	0.23	0.18	0.19	0.09	0.16	0.11	1.56	1.33	1.53
5000-9999	0.17	0.18	0.17	0.09	0.14	0.11	2.35	2.34	2.01
10000-19999	0.23	0.18	0.21	0.13	0.11	0.12	1.10	2.72	1.43
20000-49999	0.10	0.08	0.11	0.10	0.08	0.11	0.63	0.87	0.69
>= 50000	0.06	0.08	0.07	0.13	0.22	0.17	0.54	1.02	0.75

Figure 1: UKPO Patent Publications by International Patent Classification (IPC)

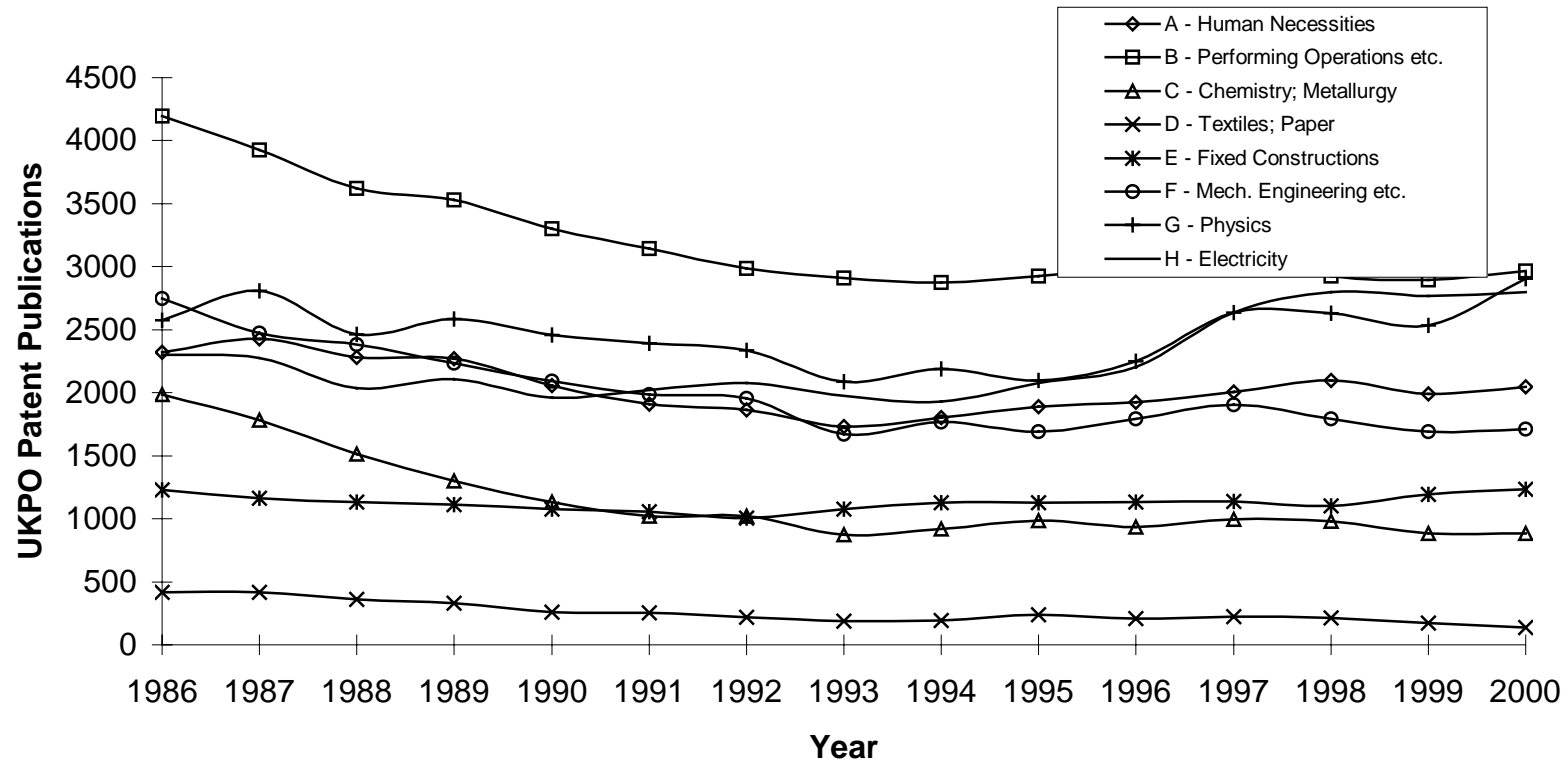


Figure 2: EPO Patent Publications by International Patent Classification (IPC)

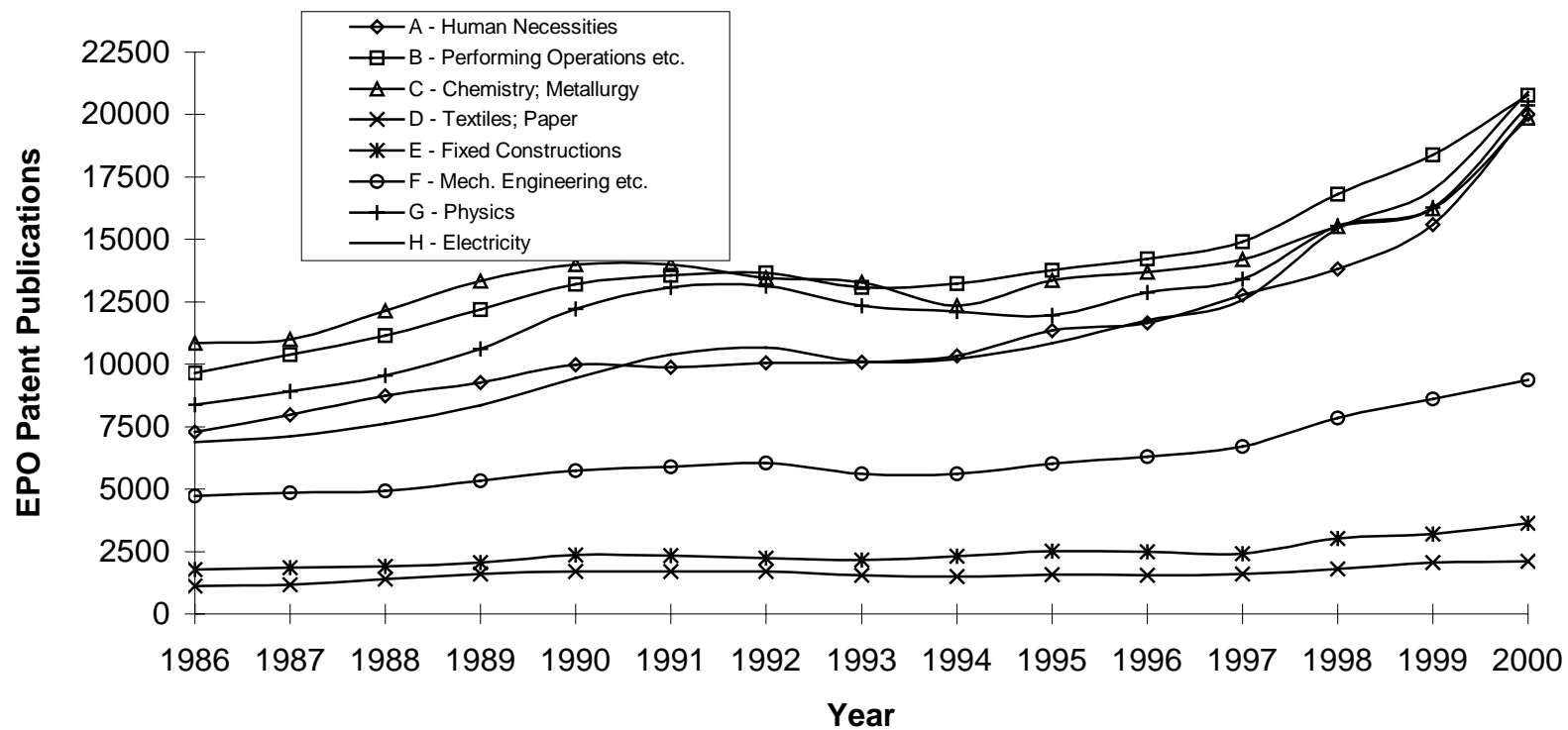


Figure 3: UK Trade Mark Applications by Goods Classes, Aggregated to Mirror IPC Sections

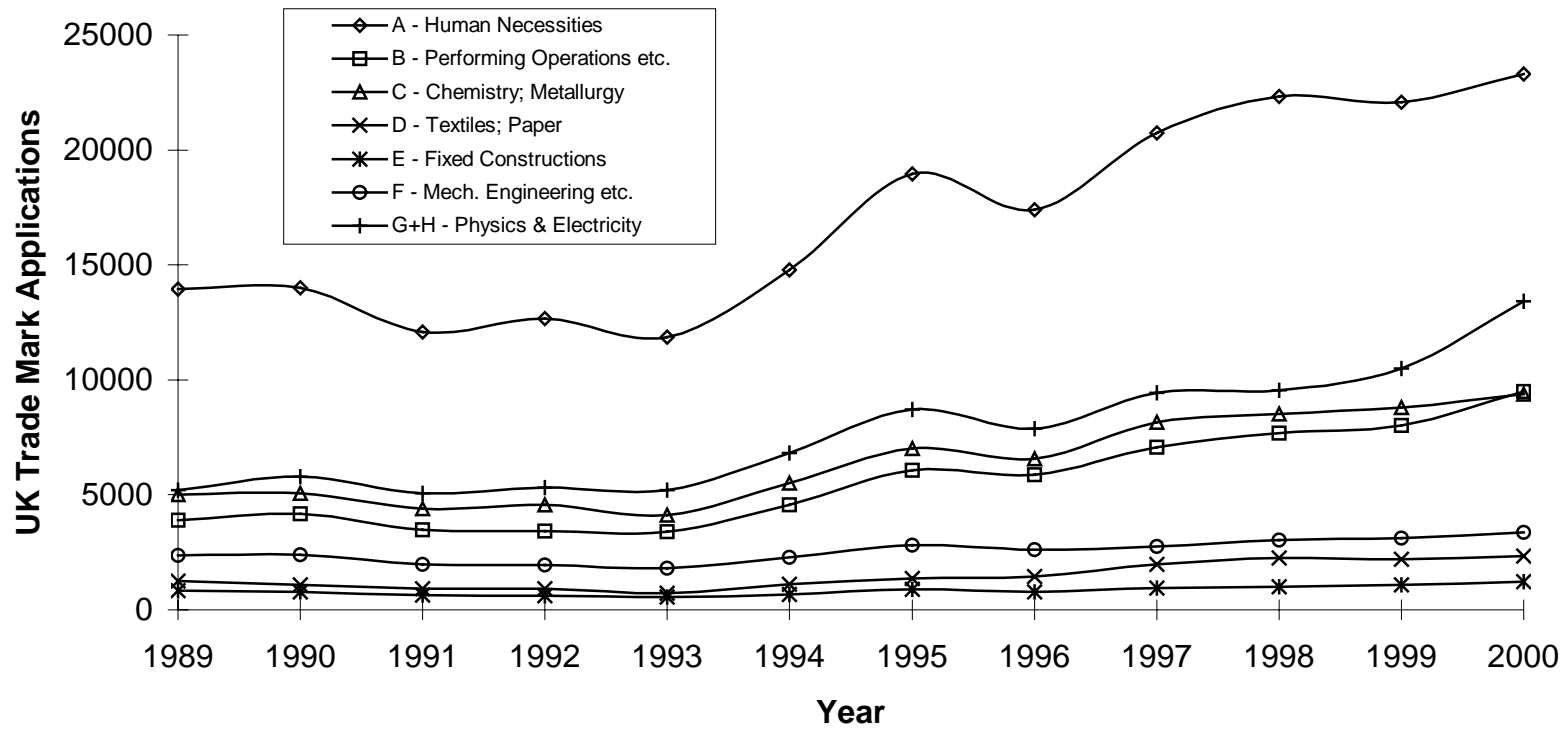


Figure 4: UK Service Mark Applications by Class of Service

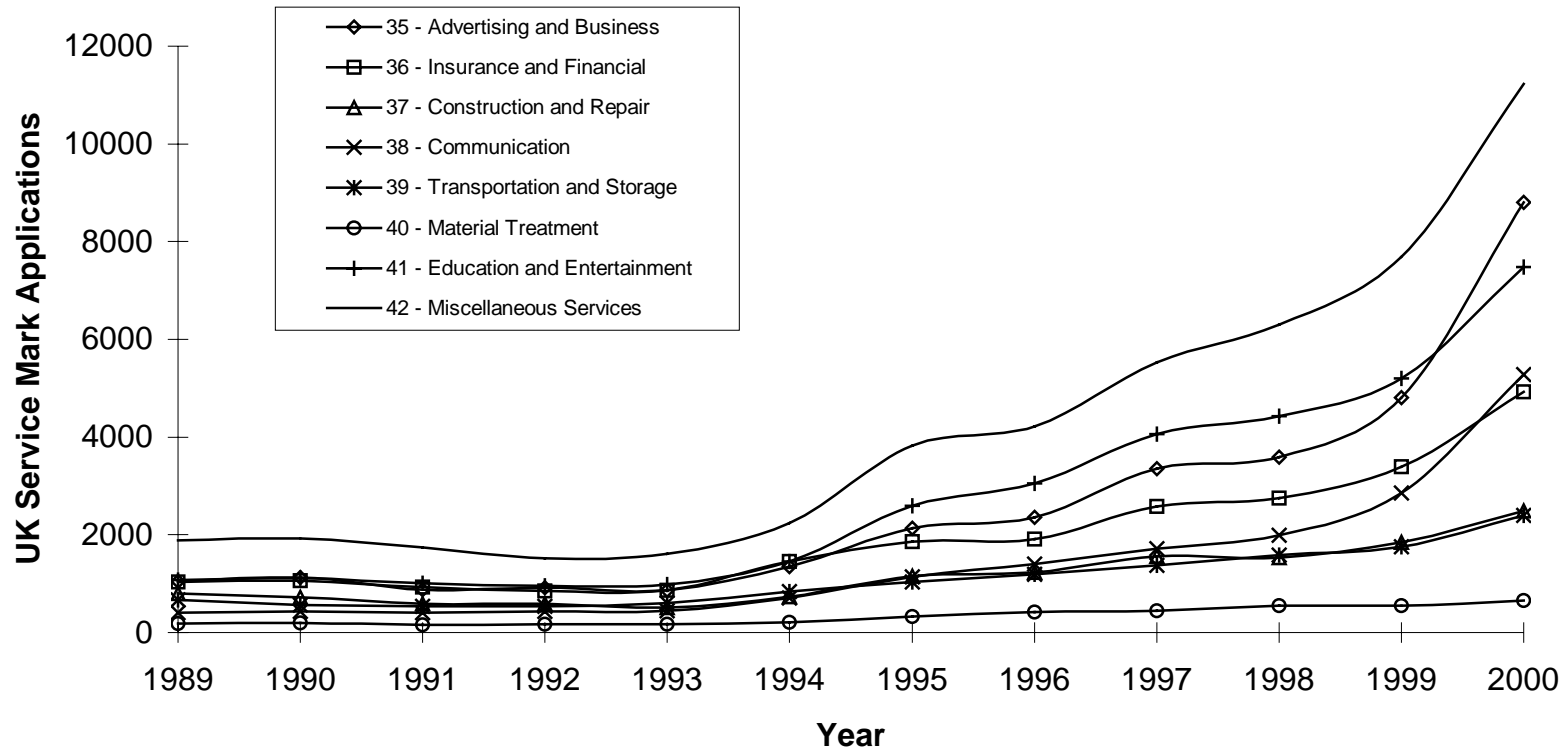


Figure 5a: UKPO patent publications versus firm sales (cumulative proportions) 1995

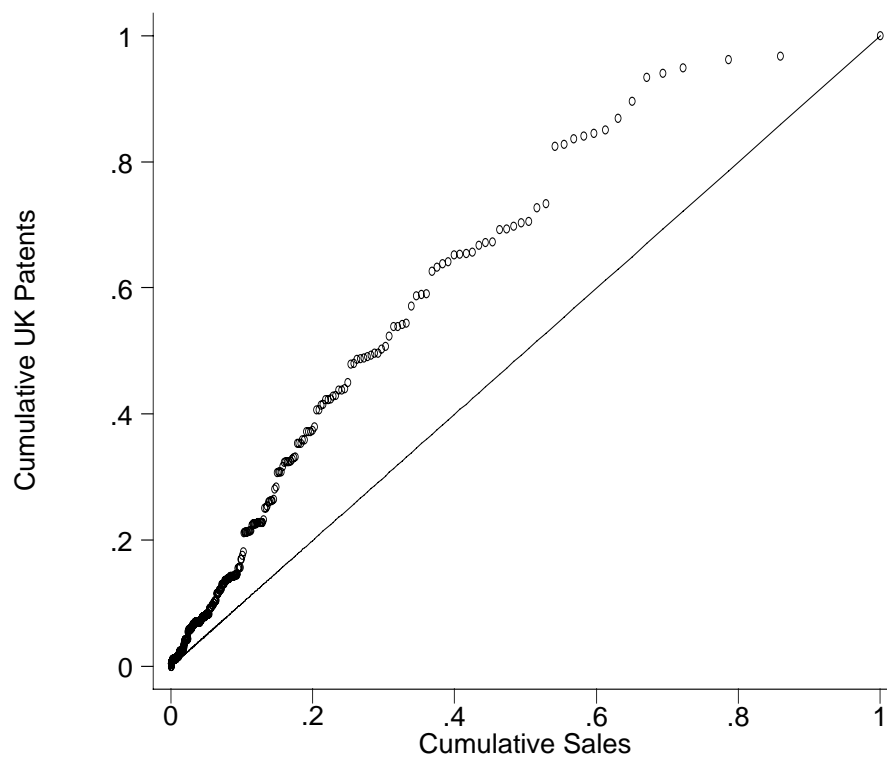


Figure 5b: UKPO patent publications versus firm sales (cumulative proportions) 2000

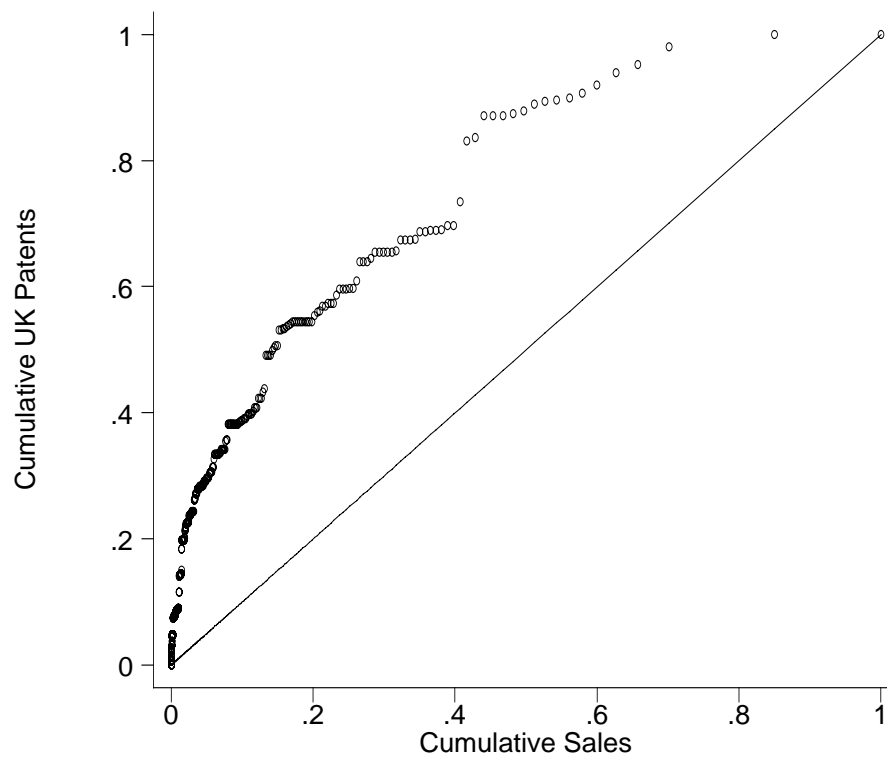


Figure 6a: EPO (des. UK) patent publications involving at least one British applicant/assignee versus firm sales (cumulative proportions) 1995

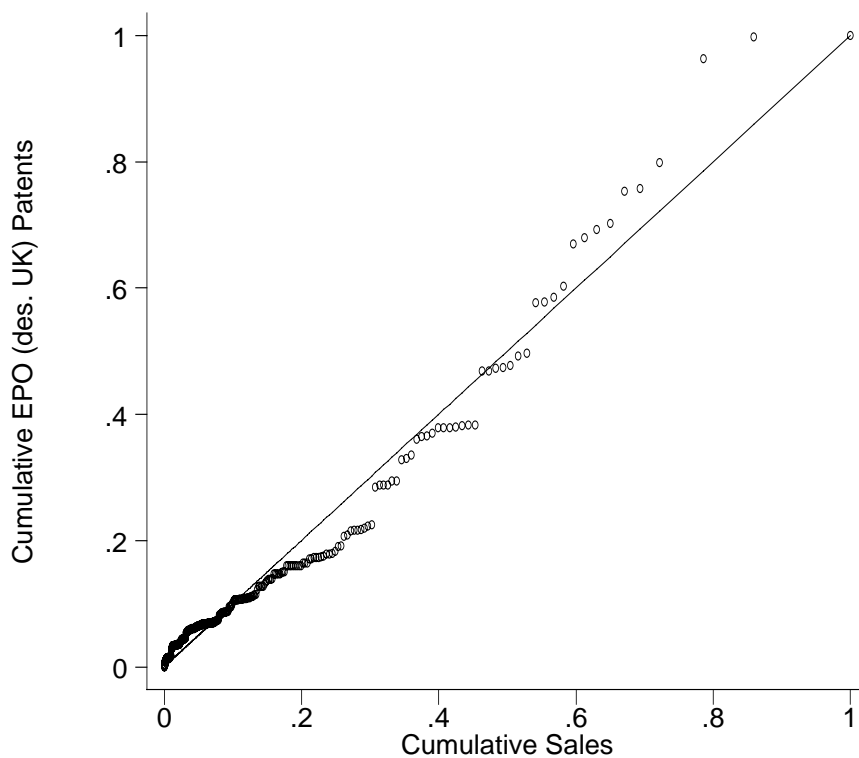


Figure 6b: EPO (des. UK) patent publications involving at least one British applicant/assignee versus firm sales (cumulative proportions) 2000

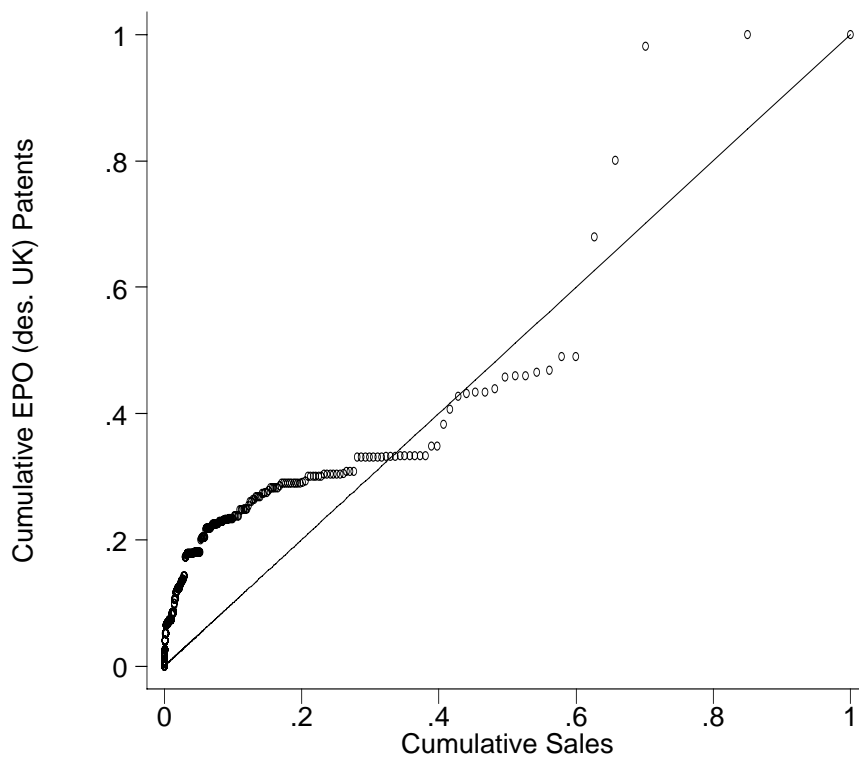


Figure 7a: UK trade mark applications versus firm sales (cumulative proportions) 1995

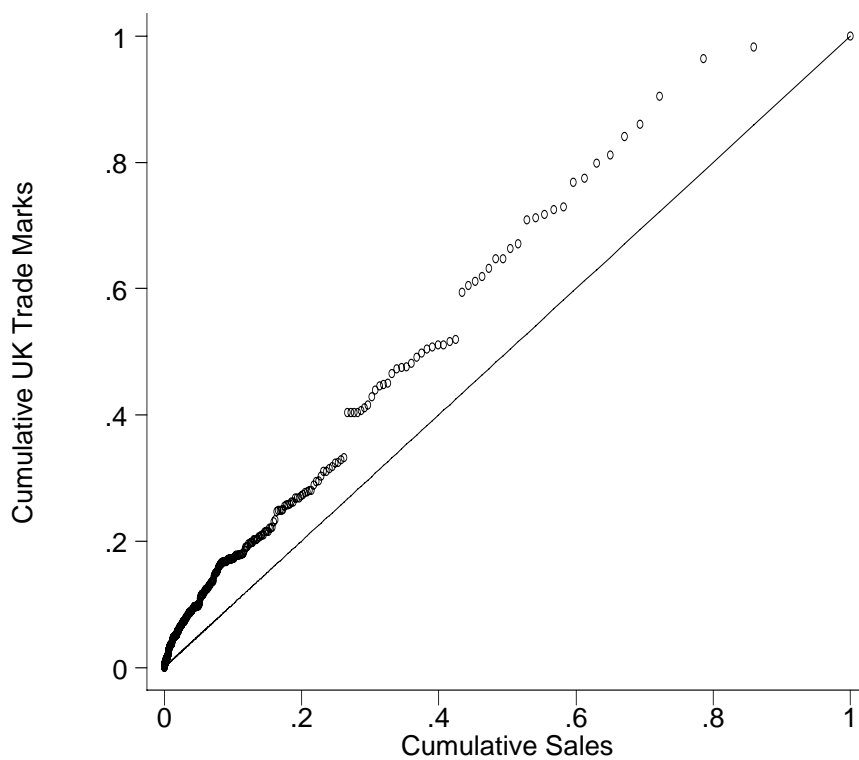


Figure 7b: UK trade mark applications versus firm sales (cumulative proportions) 2000

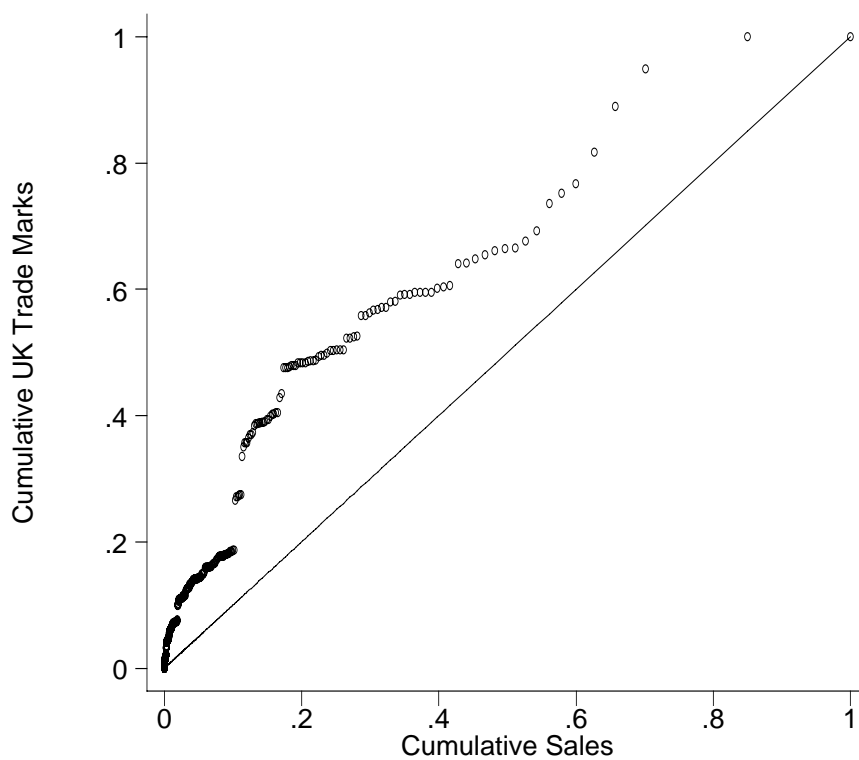


Table A1: Patents granted with effect in the UK as recorded by WIPO

Year of Grant	Grants to				Total Grants (% of Total Grants to UK Residents)	
	UK Residents		Non-Residents			
1986	(UKPO)	4610	(UKPO)	11596	16206	(28.4)
	(EPO)	793	(EPO)	15930	16723	(4.7)
		5403		27526	32929	(16.4)
1987	(UKPO)	3875	(UKPO)	9174	13049	(29.7)
	(EPO)	734	(EPO)	14876	15610	(4.7)
		4609		24050	28659	(16.1)
1988	(UKPO)	3633	(UKPO)	7823	11456	(31.7)
	(EPO)	814	(EPO)	17294	18108	(4.5)
		4447		25117	29564	(15.0)
1989	(UKPO)	3273	(UKPO)	6865	10138	(32.3)
	(EPO)	961	(EPO)	19798	20759	(4.6)
		4234		26663	30897	(13.7)
1990	(UKPO)	3265	(UKPO)	6131	9396	(34.7)
	(EPO)	1096	(EPO)	21687	22783	(4.8)
		4361		27818	32179	(13.6)
1991	(UKPO)	3307	(UKPO)	6039	9346	(35.4)
	(EPO)	1185	(EPO)	23543	24728	(4.8)
		4492		29582	34074	(13.2)
1992	(UKPO)	3331	(UKPO)	6089	9420	(35.4)
	(EPO)	1311	(EPO)	27096	28407	(4.6)
		4642		33185	37827	(12.3)
1993	(UKPO)	3019	(UKPO)	5311	8330	(36.2)
	(EPO)	1470	(EPO)	32786	34256	(4.3)
		4489		38097	42586	(10.5)
1994	(UKPO)	3517	(UKPO)	6013	9530	(36.9)
	(EPO)	1705	(EPO)	37537	39242	(4.3)
		5222		43550	48772	(10.7)
1995	(UKPO)	3646	(UKPO)	5827	9473	(38.5)
	(EPO)	1596	(EPO)	37281	38877	(4.1)
		5242		43108	48350	(10.8)
1996	(UKPO)	2737	(UKPO)	4395	7132	(38.4)
	(EPO)	1585	(EPO)	35618	37203	(4.3)
		4322		40013	44335	(9.7)
1997	(UKPO)	2792	(UKPO)	5153	7945	(35.1)
	(EPO)	1757	(EPO)	35052	36809	(4.8)
		4549		40205	44754	(10.2)
1998	(UKPO)	3168	(UKPO)	6081	9249	(34.3)
	(EPO)	1670	(EPO)	32262	33932	(4.9)
		4838		38343	43181	(11.2)
1999	(UKPO)	2910	(UKPO)	5085	7995	(36.4)
	(EPO)	1555	(EPO)	31133	32688	(4.8)
		4465		36218	40683	(11.0)
2000	(UKPO)	3003	(UKPO)	5250	8253	(36.4)
	(EPO)	1167	(EPO)	24336	25503	(4.6)
		4170		29586	33756	(12.4)

Table A2: UK trade mark applications by year of application, broken down by class

Class	Pre-1989	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	1989-2000
1 - Chemicals	18105	1162	1207	1049	999	866	1016	1200	1076	1162	1262	1297	1479	13775
2 - Paints	6216	384	320	232	356	297	437	468	400	615	552	666	701	5428
3 - Cosmetics and Cleaning Preparations	19770	1662	1662	1490	1574	1307	1823	2378	2103	2439	2841	2796	2758	24833
4 - Lubricants and Fuels	4190	231	254	271	257	148	265	293	342	442	518	459	497	3977
5 - Pharmaceuticals	30779	2097	1976	1911	2078	1737	2086	2816	2779	2631	3007	2868	3126	29112
6 - Metal Goods	10966	887	852	759	763	690	928	1143	984	1170	1363	1352	1419	12310
7 - Machinery	17208	1217	1313	1009	951	877	1070	1330	1195	1298	1403	1418	1578	14659
8 - Hand Tools	3845	344	302	190	249	211	306	418	388	502	601	648	728	4887
9 - Electrical and Scientific Apparatus	35626	4582	5211	4620	4828	4730	6224	7867	7076	8248	8250	9167	11892	82695
10 - Medical Apparatus	6021	641	723	723	778	788	936	1113	971	973	1099	1086	1243	11074
11 - Environmental Control Apparatus	11650	1069	1045	918	969	879	1169	1409	1355	1404	1556	1627	1672	15072
12 - Vehicles	8845	845	894	840	694	714	936	1120	1090	1222	1310	1224	1438	12327
13 - Firearms	670	67	46	42	39	58	38	66	78	60	85	86	125	790
14 - Jewellery	3833	570	510	390	421	422	521	760	710	1067	1206	1223	1335	9135
15 - Musical Instruments	911	64	77	50	68	59	89	97	89	112	98	111	196	1110
16 - Paper Goods and Printed Matter	21453	2721	2970	2440	2478	2459	3324	4526	4385	5359	5765	6134	7329	49890
17 - Rubber Goods	7730	553	523	438	408	360	524	625	549	679	587	647	693	6586
18 - Leather Goods	3636	645	622	482	454	444	549	944	919	1373	1453	1443	1582	10910
19 - Non-Metallic Building Materials	8476	826	788	650	618	568	669	883	791	941	991	1084	1232	10041
20 - Furniture and Articles not other. class.	7339	948	898	644	745	709	874	1120	1002	1252	1519	1584	1684	12979
21 - Housewares and Glass	6932	682	629	532	578	520	707	996	1023	1396	1568	1600	1631	11862
22 - Cordage and Fibres	1787	117	127	124	112	79	104	141	161	230	252	258	314	2019
23 - Yarns and Threads	2154	109	63	72	80	47	57	66	88	67	111	102	157	1019
24 - Fabrics	6360	587	586	416	423	362	551	623	679	931	1027	1010	1012	8207
25 - Clothing	20598	2889	3147	2430	2628	2507	3016	3799	3567	4203	4262	4307	4470	41225
26 - Fancy Goods	1780	170	144	132	134	98	145	268	229	373	476	407	388	2964
27 - Floor Coverings	2423	258	173	175	161	137	243	273	289	373	389	417	470	3358
28 - Toys and Sporting Goods	9451	1431	1515	1297	1176	1122	1357	1848	1632	2170	2210	2323	2338	20419
29 - Meats and Processed Foods	12551	1230	1144	1034	1134	1122	1329	1639	1485	1874	1974	1833	2048	17846
30 - Staple Foods	16007	1605	1519	1274	1277	1339	1755	2218	1895	2501	2585	2476	2667	23111
31 - Natural Agricultural Products	5553	534	537	504	505	510	564	707	651	780	825	803	925	7845
32 - Light Beverages	7134	588	652	539	623	634	888	1158	1177	1344	1467	1514	1578	12162
33 - Wines and Spirits	10313	566	627	623	718	669	901	1182	1112	1375	1328	1423	1438	11962
34 - Smokers Articles	5421	222	240	253	181	187	348	322	295	510	447	397	413	3815
All Goods Marks	335733	32503	33296	28553	29457	27656	35749	45816	42565	51076	54387	55790	62556	499404

Table A2 Cont.: UK trade mark applications by year of application, broken down by class

35 - Advertising and Business	3052	1054	1132	872	911	859	1352	2131	2354	3355	3595	4808	8804	31227
36 - Insurance and Financial	3695	1030	1063	936	847	860	1448	1861	1910	2579	2748	3391	4931	23604
37 - Construction and Repair	2353	794	726	595	596	514	729	1155	1233	1561	1534	1853	2489	13779
38 - Communication	1162	406	429	408	433	445	711	1136	1400	1720	1996	2854	5275	17213
39 - Transportation and Storage	2317	666	557	542	543	600	833	1029	1186	1379	1591	1760	2401	13087
40 - Material Treatment	494	179	193	161	172	175	214	328	413	450	555	550	655	4045
41 - Education and Entertainment	2292	1068	1116	1012	951	977	1457	2589	3055	4063	4422	5201	7479	33390
42 - Miscellaneous Services	5496	1881	1922	1744	1523	1613	2246	3820	4215	5533	6305	7690	11230	49722
All Service Marks	20861	7078	7138	6270	5976	6043	8990	14049	15766	20640	22746	28107	43264	186067
All Marks	356594	39581	40434	34823	35433	33699	44739	59865	58331	71716	77133	83897	105820	685471
WIPO figures		40052	39632	34983	35968	34764	42572	59053	53438	64169	65992	70887	85578	627080

Table A3: Match between patent and trade mark classes

Section of IPC	Corresponding Trade Mark Classes
A - Human Necessities	3, 5, 10, 20, 21, 25, 28, 29, 30, 31, 34
B - Performing Operations; Transporting	8, 12, 16
C - Chemistry; Metallurgy	1, 2, 4, 6, 17, 18, 32, 33
D - Textiles; Paper	22, 23, 24, 26, 27
E - Fixed Constructions	19
F - Mechanical Engineering; Lighting; Heating; Weapons; Blasting	7, 11, 13
G - Physics	9, 14, 15
H - Electricity	Elsewhere (mostly G)
Unclassified - Others	None

The sections of the International Patent Classification (IPC) correspond to those given by WIPO (1997). To obtain a full listing please refer to WIPO.

On attempting to collapse the 34 goods trade mark classes into 8 categories mirroring the IPC, we assigned them in accordance with the above. The matching was undertaken by comparing trade mark descriptions given in the detailed "List of Classes, 6th edition of the Nice Agreement", against explicit definitions of the technology sections of the 6th edition of the IPC (WIPO, 1997).

Table A4: International trade and service mark classes**Goods**

1 Chemicals	18 Leather Goods
2 Paints	19 Non-Metallic Building Materials
3 Cosmetics and Cleaning Preparations	20 Furniture and Articles Not Otherwise Classified
4 Lubricants and Fuels	21 Housewares and Glass
5 Pharmaceuticals	22 Cordage and Fibres
6 Metal Goods	23 Yarns and Threads
7 Machinery	24 Fabrics
8 Hand Tools	25 Clothing
9 Electrical and Scientific Apparatus	26 Fancy Goods
10 Medical Apparatus	27 Floor Coverings
11 Environmental Control Apparatus	28 Toys and Sporting Goods
12 Vehicles	29 Meats and Processed Foods
13 Firearms	30 Staple Foods
14 Jewellery	31 Natural Agricultural Products
15 Musical Instruments	32 Light Beverages
16 Paper Goods and Printed Matter	33 Wines and Spirits
17 Rubber Goods	34 Smokers Articles

Services

35 Advertising and Business	39 Transportation and Storage
36 Insurance and Financial	40 Material Treatment
37 Construction and Repair	41 Education and Entertainment
38 Communication	42 Miscellaneous Services

This concise listing corresponds to that given by MicroPatent (1995). To obtain a full listing please refer to WIPO.

Table A5: Production firms - Mean numbers of EPO (designating the UK) patent publications by year

US SIC	Firms	1996	1997	1998	1999	2000	1996-2000	96-00
15 General Building Contractors	35	0.0	0.1	0.1	0.1	0.1	0.1	12
20 Food & Kindred Products	35	5.5	5.5	5.1	5.0	5.4	5.3	924
27 Printing & Publishing	24	0.0	0.0	0.0	0.2	0.1	0.1	10
28 Chemicals & Allied Products	37	7.6	7.4	6.7	6.8	9.8	7.6	1415
32 Stone, Clay & Glass Products	19	0.7	0.7	0.8	0.5	1.0	0.7	71
34 Fabricated Metal Products	20	0.6	0.4	0.6	0.8	0.6	0.6	60
35 Industrial Machinery & Equipment	34	2.1	2.4	2.1	3.7	3.9	2.8	482
36 Electronic & Other Electric Equipment	33	0.8	1.3	1.5	1.5	2.3	1.5	245
37 Transport Equipment	27	2.0	2.2	2.9	3.1	2.7	2.6	349
38 Instruments & Related Products	32	2.9	2.8	2.5	3.3	5.3	3.3	536
49 Electric, Gas & Sanitary	20	0.2	0.2	0.6	0.3	0.6	0.4	38
10-49 All production	487	2.1	2.0	2.0	2.2	2.7	2.2	5736

Note: Unlike Table 6b, this table considers all EPO (des. UK) patent publications, not just those having at least one British applicant/assignee.

Table A6a: Cross tabulation of UKPO patent publications against EPO (des. UK) patent publications, for the five year period 1996-2000

UKPO Publications 1996-2000	EPO (des UK) Publications 1996-2000						Total	
	None		1-5		6+		No.	%
	No.	%	No.	%	No.	%		
None	250	(51.33)	24	(4.93)	11	(2.26)	285	(58.52)
1-3	50	(10.27)	31	(6.37)	17	(3.49)	98	(20.12)
4+	9	(1.85)	30	(6.16)	65	(13.35)	104	(21.36)
Total	309	(63.45)	85	(17.45)	93	(19.10)	487	(100)

Pearson Chi² (4) = 247.80 Pr = 0.000

Note: Unlike Table 10a, this cross tabulation considers all EPO (des. UK) patent publications, not just those having at least one British applicant/assignee.

Table A6b: Cross tabulation of EPO (des. UK) patent publications against UK trade mark applications, for the five year period 1996-2000

EPO (des UK) Publications 1996-2000	UK TM Applications 1996-2000						Total	
	None		1-11		12+		No.	%
	No.	%	No.	%	No.	%		
None	137	(28.13)	100	(20.53)	72	(14.78)	309	(63.45)
1-5	18	(3.70)	35	(7.19)	32	(6.57)	85	(17.45)
6+	4	(0.82)	30	(6.16)	59	(12.11)	93	(19.10)
Total	159	(32.65)	165	(33.88)	163	(33.47)	487	(100)

Pearson Chi² (4) = 75.81 Pr = 0.000

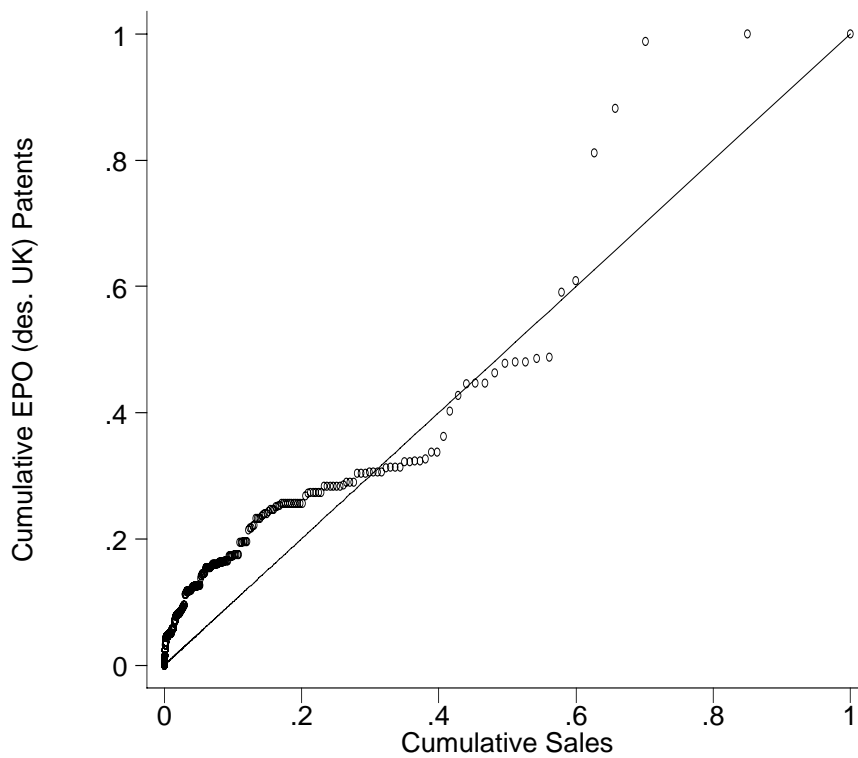
Note: Unlike Table 10c, this cross tabulation considers all EPO (des. UK) patent publications, not just those having at least one British applicant/assignee.

Table A7: Production firms 1996-2000 - Mean numbers of EPO (des. UK) patent publications per thousand workers by firm size

Total Employment	1998	2000	1996-2000
< 100	6.28	4.38	7.02
100-199	1.22	5.15	2.44
200-499	1.48	0.78	0.96
500-999	0.81	0.81	0.46
1000-1999	0.42	0.96	0.51
2000-4999	0.13	0.24	0.17
5000-9999	0.17	0.27	0.30
10000-19999	0.33	0.28	0.26
20000-49999	0.15	0.18	0.20
>= 50000	0.23	0.53	0.32

Note: Unlike Table 11b, this table considers all EPO (des. UK) patent publications, not just those having at least one British applicant/assignee.

Figure A1: EPO (des. UK) patent publications versus firm sales (cumulative proportions) 2000



Note: Unlike Figure 6b, this graph considers all EPO (des. UK) patent publications, not just those having at least one British applicant/assignee.

Appendix: Technical Notes on the Construction of the Extended Database

Constructing firm level data for 1996-2000⁴

Firms financial information was obtained from Company Analysis (Thomson, 2001) for firms in the US SIC categories 10 to 49 (including production, construction and utilities sectors), which had reported financial accounts in the UK. In order to explore the IP assets acquired by these companies during the period of interest we needed to know which firm names formed part of the group reporting the accounts, in order to include all IP which could have contributed to the overall performance of the financial group.

We obtained “Who Owns Whom” information from a 2001 Q4 CD-ROM (Dun & Bradstreet International, 2001) and 1498 family trees were downloaded.⁵ Each of these trees detailed a parent firm and all of its subsidiaries. The family trees included the subsidiary information of 1192 British parent firms in the production, construction and utilities sectors. The other 306 family trees headed by foreign firms were mainly obtained because they were the parents of British production firms for which we had access to financial account data (from Company Analysis). Some foreign firms were of interest for other reasons, typically they were known to be very active in protecting their IP assets via UK, EPO or US patent, or UK trade mark systems. In total, the 1498 family trees accounted for 94,538 firm names (an average of 62.1 subsidiaries per group). A further 48,829 variant firm names (generated in accordance with the procedures described below) were included for the matching process.

Financial accounts and possible firm types

Three possible firm types were identified of firms for which company accounts were available during part or all of the period 1996-2000:

Group A: British parent firms with one or more British or foreign subsidiaries reporting group financial accounts in the UK,

Group B: British firms reporting sub-group accounts in the UK with either British or foreign parents,

Group C: possible ‘stand alone’ firms, for which the name did not appear in “Who Owns Whom” and therefore might be deemed to have had no parent or subsidiaries.

The financial data from Company Analysis registers whether the named firms had ceased to exist, having gone into liquidation or disappeared through takeover, or were still alive trading under this name in 2000; this is illustrated in the following table.

From Table A8 it can be seen that there is considerable re-organisation of ownership and a large number of changes in name. Those which had either ceased trading or been absorbed into another company through mergers and acquisitions considerably outnumbered those for which there was late reporting of accounts at the end of the period. Fortunately the number of UK ultimate parent firms which were in existence throughout the period was still sizeable and this is the group which is used for the main part of our analysis in this paper.⁶

⁴ Financial data and IP counts for the period 1986-1995 which formed the original database were constructed in a similar manner to that described here for the extended database for 1996-2000. The earlier counts were obtained using firm ownership structure as recorded in “Who Owns Whom” (Dun & Bradstreet International, 1994). For further details see the Appendix Notes in Greenhalgh and Longland (2001).

⁵ Some of these trees contained information on more than one firm reporting accounts (see Table A8 below).

⁶ The numbers of firms used is smaller than the number in Table A8 because of missing observations in individual years or because for specific analyses interest was restricted to a panel.

Table A8: Classification of sample firm types in extended database

Information on status of the firm from Company Analysis data source (2001)	Group A: British firms ultimate parents 912 firm names	Group B: British firms not ultimate parents 675 firm names	Group C: possible 'stand alone' firms 373 firm names
No longer reporting financial accounts in this name (i.e. ceased trading or taken over/merged)	237 firms	565 firms	307 firms
Still reporting financial accounts in this name (accounts available in 2000)	675 firms (541 firms)	110 firms (23 firms)	66 firms (42 firms)

Firms in Group B were not included in the main analyses of IP based on matching IP counts by name, partly because so few remained in existence throughout the period, but mainly because it was very difficult to distinguish which patents or trade marks belonged to the UK group and its own subsidiary and associate companies rather than to the ultimate parent and the wider international group.

Table A9: Production firms - Mean numbers of intellectual property acquisitions by year for 28 British 'stand alone' firms

	1996	1997	1998	1999	2000	1996-2000	Total 96-00
UKPO patent publications	0.1	0.0	0.1	0.1	0.2	0.1	16
EPO (des. UK) patent publications	0.0	0.0	0.0	0.0	0.1	0.0	4
UK trade mark applications	0.3	0.5	0.4	0.6	4.4	1.3	175

The number of firms identified as being 'stand alone' is extremely small. Two illustrative examples of firm names in Group C which were missing from "Who Owns Whom" in 2001, but traced as not being live 'stand alone' firms after further investigation using the Fame (Bureau van Dijk, 2003) company accounts data follow. These were: British Gas, which was initially BG PLC, then BG Transco PLC in Dec.1999, then Transco PLC in Oct 2000; and Bell Cablemedia PLC, which changed to become Cable and Wireless Communications (B)

PLC in Feb. 1999, after which there were two further name changes, finally becoming NTL (B) Ltd, a subsidiary of NTL Inc.

Although we had originally hoped to analyse Group C fully, the small numbers made it impossible to do more than record their overall IP activity. Table A9 analyses the panel of firms alive throughout 1996-2000. The rows in this table correspond to the bottom rows of Tables 5b, 6b and 7b. In each case, it can be seen that these ‘stand alone’ firms have acquired far fewer IP assets than the firms with subsidiaries.

Generating and using firm name variants in the matching process

Matches against the list of all “owners” (including joint proprietors) of the three types of IP were made for all names appearing in the family tree of the parent firm. The matches were of two types –

Perfect: the names on the “Who Owns Whom” CD had to match perfectly with the names of the owners of the different types of IP;

Perfect trimmed: the names on the “Who Owns Whom” CD had the last word, and all previous words which formed part of the list of standardized company designations (see Technical Appendix of Greenhalgh and Longland 2003), or the ampersand character, removed from their names.

Working from the end of a name to the beginning, we were happy to remove any number of such words, provided that the name was not reduced to nothing. Hence, if a name was reported on the “Who Owns Whom” source as consisting of just one word, it would not be shortened – therefore the full name would be identical to the trimmed version of the name.

To improve the likelihood of success on matching between databases, common abbreviations accommodated to generate counts for individual IP owners were applied to the names of family members. Variants of names reported on the “Who Owns Whom” source were also investigated. The variants largely related to names that arguably started with initials. If the initials were separated by spaces, a variant would be created with the spaces between the initials removed. Further variants having the initials (with and without spaces) moved from the start of the name to the end of the core part of the name, immediately prior to the trimmed component, were also used for matching purposes.

Alternatively, initials need not be separated by spaces. In such cases, it is difficult to know whether characters depict initials (rather than words) and how many characters are likely to represent initials. In practice, all first words of less than four characters were taken to be initials. These initials had spaces inserted between them to permit the creation of the first variant, which retained the initials at the beginning of the firm’s name. The two further employed variants correspond to those discussed above for initials originally separated by spaces. That is, the initials (with and without spaces) were moved from the start of the name, to the end of the core part of the name immediately prior to the previously determined trimmed component.

Some names beginning with initials, were followed by an ampersand and more initials. In these cases, the term “initials” is used to refer to the characters up to and including the last initial after the ampersand. That is, unless the last such initial is in turn followed by another ampersand and potentially more initials. If that happened the number of characters of initials would be increased accordingly. The insertion/removal of spaces between these initials would only generate one additional variant of the initials, unless the initials before and after the ampersand(s) were reported differently on the employed “Who Owns Whom” source. That is, we did not seek to generate variants of initials permitting different spacing treatments

before and after ampersands. Since we were happy not to restrict such initials to a maximum of one ampersand, this seemed perfectly reasonable. If a name had just one initial, or each initial before and after ampersand(s) consisted of just one character, only one variant was applicable – the one where initials were moved to the end of the core part of the name. This is because, in this case, the initials and spaced out initials are identical.

Further variants were generated to insert a space between the terms/words “UK” and “GB” appearing within the names of some family members. Other instances of “UK” and “GB” already contained a separating space. If this was the case for a parent, or subsidiary firm, a variant would be generated having had the referred to space removed. The four British identifiers described above, all corresponded to characters appearing after the starting initials (if any) within firm names. When one considers that names could include both initials and British identifiers, it should be clear that for some names a number of variants were included for possible matching against the owners of the different IP types. As one would expect, for all generated variants of family member names, the appropriate trimmed variant was also used for the matching process.

If an IP owner was matched both perfectly against a full name or variant, and perfectly against a trimmed name or variant from the “Who Owns Whom” source, then only the perfect full match was considered. Hence suggestions that the IP owner was applicable to one or more groups via the trimmed match would be discarded. Acceptable matches whether perfect, or perfect trimmed were then scanned to see the number of groups to which each matched name related. If only one group was suggested, it was felt perfectly reasonable to accept the match.

If two groups were suggested, we investigated the nationalities of the matched family members, in the cases where the 1996-2000 count of the IP owner exceeded selected thresholds, to determine appropriate matches.⁷ All other matches potentially attributable to two groups but not exceeding the threshold during the 5 years, were accepted for both groups. This is not desirable and is likely to distort the counts applicable to certain groups. However, other factors such as changing company structures and firm ownership exist, and therefore indicate the need for the reader of this paper to be aware that group counts are under other, potentially more significant, influences affecting their accuracy.

If three or more groups were suggested, irrespective of the total IP count of the owner, the original IP database or a web-based version was consulted to see which, if any of the suggested matches seemed appropriate. We could do this because three or more suggested groups only happened for perfect trimmed matches. Typically, the suggested matches corresponded to a company designation (or common word) given as a joint applicant for an IPR since our trimmed versions of names from the “Who Owns Whom” source, could not be shortened to nothing, they could be trimmed, for example to a company designation (or common word) or initials identical to a company designation. In all such cases, we were not happy to accept any of the suggestions.

⁷ In the case of EPO patents, matches to only one group by the trimmed match were also checked using nationality if the appropriate threshold was exceeded.