

Chapter 14

Firm Size and Intellectual Property Management¹

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1. Introduction

Small firms are not simply mini-versions of large companies. They are fundamentally different business entities in terms of nearly all aspects of a business including business strategies, organizational structure, available financial and human resources and so forth. These differences offer advantages and drawbacks. As Roberts (1980: 137) concisely puts it: “Small entrepreneurially minded companies have been unusually able to come up with technological advances that are competitive in the marketplace. But the small company has an obvious problem: its size.” This suggests that a firm’s size might also have important implications for the way a firm uses intellectual property (IP). This chapter discusses the relation between firm size and IP. It discusses differences in how firms of different size employ the IP system. The chapter shows that the use of the IP system differs across firm size categories and explains some of the underlying reasons for these differences which have direct implications for firms’ IP strategy.

Standard IP management text-books commonly discuss IP management independently of firm size.¹ This is useful in identifying general principles that apply broadly to IP management. In practice, however, firms of different size face dramatically different challenges imposing substantially different constraints on a firm’s IP management. Hence, from a practitioner’s perspective,

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awareness of the differences in challenges and constraints is useful in achieving successful IP management. From a policy perspective, a discussion that distinguishes between firm size categories helps uncovering the different difficulties firms face in the different size categories. It also helps shedding light on competitive as well as cooperative interactions between firms of different size categories, which may motivate policy intervention. Finally, from a research perspective, analyzing small-firm IP use is particularly interesting because of the presence of enormous variation across firms in terms of innovation and IP use. Also, interaction between small and large firms in the product market as well as the market for technology is a promising, but so far under-researched area.

This chapter distinguishes broadly between small and large firms which comprise four types of firms: micro firms, small and medium-sized enterprises (SMEs), large domestic companies, and multinational enterprises (MNEs) and business groups. Naturally, the discussion also distinguishes by sector of business activity as this has important implications for the type of IP applicable. Start-up companies are subsumed under the micro and SME categories or addressed separately when adequate. Regarding the definition of the concepts of innovation and IP discussed here, we rely on the exhaustive treatment of the relevant issues in the preceding chapters.

The main objective of this chapter is to discuss the differences in the challenges and constraints small and large firms face in terms of IP use. The most salient difference between small and large firms is the availability of financial and human resources. This is an issue not only in terms of the expertise on the IP system available to the company but in particular when it comes to the decision whether to seek costly patent protection and whether to maintain existing patents in force. These resource-based differences become most visible when it comes to IP litigation. The ability of a patent holder to sue a third party for infringement requires monitoring of third parties' activities. And when a firm is accused of alleged infringement or detects a third party to infringe its own IP rights, the firm's ability to engage in costly litigation depends to a large extent on how deep its pockets are. The scarce available evidence suggests that small firms are at a significant disadvantage when they are involved in litigation (Lanjouw and Schankerman, 2004; Greenhalgh et al., 2010). While there is even less empirical evidence, opposition to the registration of trademarks may be equally costly and large firms may in particular target trademark registrations of smaller firms. The US food company Kellogg Co. for example, leads in terms of trademark oppositions in the US with 224 filings before the Federal Trademark Trial and Appeal Board of the USPTO (Halcom, 2010). This behavior suggests that the firm closely monitors new trademark filings at the USPTO which only a large company can afford.² Moreover, the organizational challenge for large firms to organize their IP management is very different from that of small firms. Small firms need to establish an IP strategy and mobilize internal and external resources to translate the strategy into practice. Small firms often design their business model without consideration of the future role of IP, which is likely to create difficulties as soon as the company engages in competition. Small firms may even face a trade-off in whether to invest in protection of existing inventions or in the development of new technology (Kitching and Blackburn, 2003). Large firms, in contrast, have to decide which organizational structure to adopt. Options range from a centralized, specialized, and generously staffed IP management department to an external supplier, such as a patent agent or attorney. The choice has important implications for the role IP will play within the organization, its business strategy and ultimately the company's success.

Some of the relevant issues with regard to IP are also due to technological developments in certain industries. A number of industries, such as the bio-tech sector, are characterized by increasing technological interdependencies. This means that single patents can be of little value as freedom-to-operate is only achieved by cross-licensing large patent portfolios. This may put small firms inherently at a disadvantage. However, at the same time, it may also provide opportunities for smaller firms that do not manufacture end-products to obtain licensing income. A related issue that affects large and small firms differently concerns industry standards. In particular in industries that are characterized by technological interdependencies between products and services, such as telecommunication, compatibility is a central concern. If standards are set by the dominant players in a market, small firms may be at a disadvantage. Similarly, increased internationalization of business activities confronts firms with the necessity to think global also with regard to their IP strategy. This may foster the formation of international business groups and negatively impact on the ability of smaller stand-alone companies to effectively engage in competition. It may, however, also give rise to 'born global' SMEs (Cavusgil and Knight, 2009), i.e., firms that build their business model on their ability to engage in business and innovative activities world-wide. The following sections discuss these and other issues in more detail.

The chapter is organized by motivation/barrier to the use of the IP system differently across firm size categories because the issues mentioned above cut across all size categories. Section 2 discusses the empirical evidence on innovation and IP use across the different size categories. Section 3 discusses in detail issues surrounding IP management for firms in the different size categories. Section 4 concludes.

2. Empirical Evidence on Innovation and IP Use and Firm Size

This section provides a brief definition of the different firm size categories and discusses the available empirical evidence on differences in innovative activity and IP use across the different firm size categories.

2.1 Size Definition

Firms of different size distinguish themselves along different observable and unobservable dimensions. Therefore there are many different ways of defining a firm's size category. Limiting ourselves to observable firm characteristics, a standard way is to apply the OECD (2005) classification which defines SMEs as firms with between 10 and 250 employees. Firms with less than 10 employees are micro firms and those with more than 250 are large firms. The OECD notes that this definition may vary by country. In the US, for example, the upper limit is set at 500 employees instead of 250. Micro-sized companies are also often defined to have up to 49 employees and hence SMEs to have between 50 and 249 employees. The European Union also uses financial data to define size bands. Firms with turnover between over EUR 2 million and EUR 50 million are classified as SMEs. Firms with less than EUR 2 million in turnover are micro companies and firms with more than EUR 50 million are large firms. Another critical element in the classification of firm size categories is the ownership structure of firms. It is necessary to treat subsidiaries of large companies that fall into the micro firm or SME categories according to their turnover or number of employees differently

from independent micro firms or SMEs. As discussed in more detail below, large business groups may rely on complex IP management strategies which makes it often difficult to associate patents held by the holding company with the entity that conducted the underlying research and development. This not only creates difficulties for researchers but also for competitors monitoring their IP activities.

2.2 Empirical Evidence

From an economic perspective, despite the fact that large firms account for only a tiny share of an economy's total number of firms, large firms account for a sizeable share of GDP, employment, and R&D expenditure (OECD, 2010). According to the OECD, the share of large firms in total employment varies between 15.4% in Greece and nearly 46% in the UK. In most large OECD economies, large firms have employment shares of above 30%. Large companies' share in total value added is even larger, accounting for well over 40% of total value added in most large OECD economies, with a maximum of almost 55% in Korea. This is remarkable, as large firms account for barely 1% of the total number of establishments in Korea. The disproportionate economic contribution of large companies justifies the dominant interest in large firm innovation and use of intellectual property.³

There is a large literature that originates in Schumpeter (1942) which focuses on innovation in large firms.⁴ Large firms have a large amount of physical and financial assets, developed organizational structures and human resources, and usually formalized R&D departments. Innovation in large firms, therefore, is a structured process that is initiated in a firm's R&D department and then directly passed on to the manufacturing and marketing departments where the overall process is organized and monitored by a management department. Given this structured innovation process and the available financial resources, large firms produce routinely innovations which are protected and commercially exploited on the basis of a formal IP strategy which is commonly managed by specialized IP managers. As a result, large companies usually have large and actively managed IP portfolios. For example, the USPTO granted IBM 3,125 patents in a single year in 2007 contributing to its stock of more than 38,000 patents.⁵ According to its 2008 reports, Petrobras, a large Brazilian energy company, has 779 domestic patents in force and 1,396 patents in 68 countries abroad. The company also holds 232 trademarks in Brazil and 112 trademarks that are registered in 106 countries worldwide.⁶

The dominant performance of large companies diverts attention from the economic importance of small firms. In absolute numbers, SMEs and micro firms account for the overwhelming share of all registered businesses in any economy; data from the OECD (2010) show that micro firms and SMEs combined account on average for more than 99% of all registered companies in OECD economies. In Australia, Greece, Italy, Portugal and Turkey, they even account for 99.9% of all firms. With regard to innovation, research in various countries shows that small firms are not less innovative than large firms (for the US: Acs and Audretsch, 1988, 1990; for Canada: Baldwin and Gellatly, 2003). Statistics separating R&D expenditures for small and large firms show that small firms (<250 employees) in OECD countries accounted on average for only 17% of total R&D expenditures in 2001 (OECD, 2005). However, there is a considerable amount of variation, with small firms accounting for 65% in Italy and 7% in Japan. More detailed Canadian data for 2005 shows that there are 16,886 small,

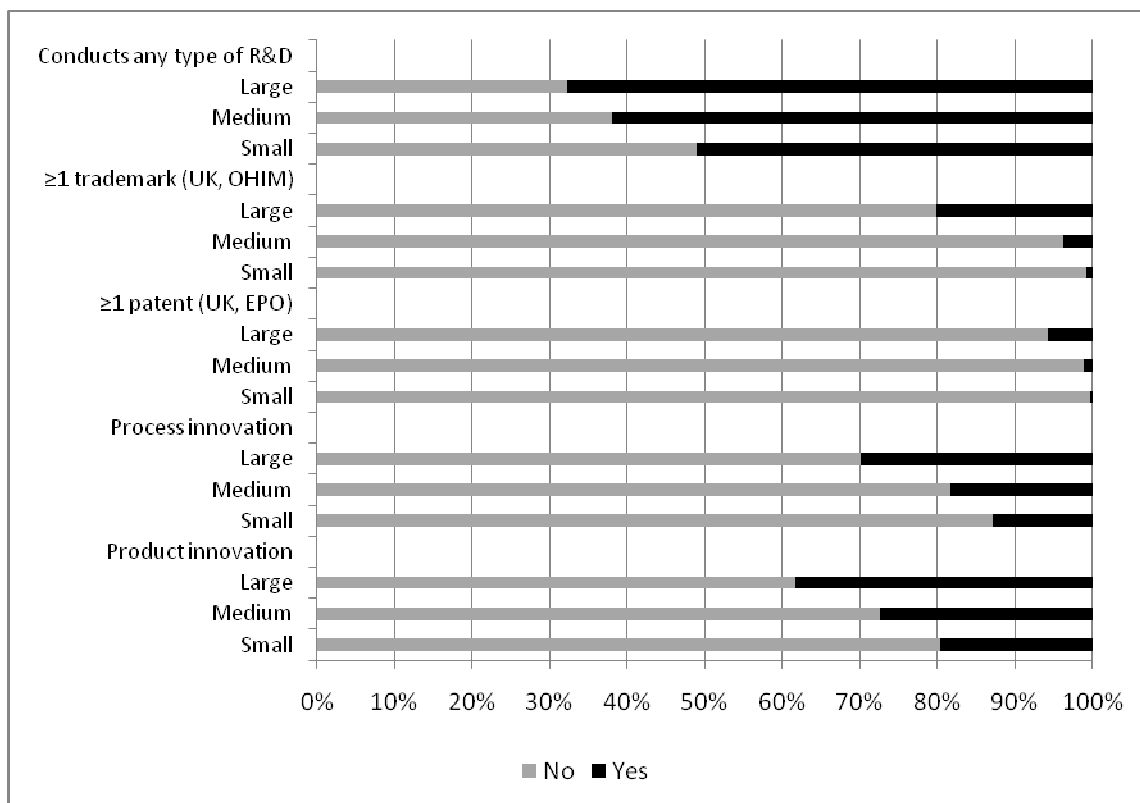
innovative firms in the economy that spend on average significantly less on R&D than the 137 largest companies (≥ 2000 employees) in Canada.⁷ The average R&D expenditure of a small company amounts to Can\$ 0.2 million whereas companies in the largest size category (≥ 5000 employees) spent on average Can\$ 61.8 million on R&D in 2005. The data, however, masks the fact that as a share of revenue, small firms are more R&D intensive. The R&D intensity data is only available for the small firm category for firms sized 1-49 employees; it shows that these small firms spend 5% of company revenues on R&D, whereas firms in the largest size category (≥ 5000 employees) spend only 1% of revenues on R&D. While this suggests that small firms are more R&D intensive, quality and value of innovations may still differ across size categories, which makes it difficult to provide an unambiguous interpretation to these numbers in absence of more detailed information (Tether, 1998). Rosen (1991), however, suggests that smaller firms tend to choose high-risk high-return innovation projects, which explains why smaller companies make a disproportionate number of drastic innovations despite their, in absolute numbers, lower investment in R&D. Supportive of this view, Canadian survey data on firms' innovative activities also show that a larger fraction of firms in the small firm category engage in product innovation and a far smaller part in process innovation than in the large firm category. This evidence thus suggests that small firms are not less innovative than large firms, but that there exist differences in the way innovation is generated and probably in the type of innovation that is created as will be discussed in more detail in Section 3.1.

Regarding firms' use of the IP system, there is evidence suggesting that in absolute numbers, SMEs and micro firms use the IP system to a comparable degree as large firms. Helmers and Rogers (2009a) show descriptive evidence for firms in the UK, suggesting that micro firms and SMEs account together for around 50% of all patents held by companies registered in the UK during 2000-2007. The authors find that large firms hold on average more patents than micro firms or SMEs, but the absolute number of patenting micro firms and SMEs is larger. Rogers et al. (2007) report similar evidence on trademarks for the UK. Jensen and Webster (2006) analyze the IP activities of Australian SMEs as well as large companies to yield similar conclusions. Their data also shows a similar pattern for the use of industrial designs. These findings are interesting as they suggest that patenting propensities among small and large firms differ. In fact, Acs and Audretsch (1989a) show that capital intensity within sectors is negatively associated with direct measures of innovation, but it is positively correlated with patent counts. This implies that the propensity to patent inventions is found to be higher in more capital intensive industries, i.e., industries dominated by large firms.

Figure 1 shows complementary evidence for UK firms available from three Community Innovation Surveys (CIS 3, 4, and 5). We combined the three surveys to cover the period 1998-2000 and 2002-2006.⁸ The graph shows firms' responses to questions in the survey regarding their innovative activity.⁹ The figure also shows information regarding firms' actual IP holdings. The data come from a match of UK and EPO (designating the UK) patents and UK and OHIM (Community marks) trademarks to the population of UK firms that we have linked with the CIS data.¹⁰ The data shown in Figure 1 confirm that a larger fraction of large firms conducts some form of R&D. Yet, more than half of small and medium-sized firms also indicate to conduct some kind of R&D.¹¹ Large firms are also much more likely to use formal IP in the form of trademarks and patents. Note that the graph does not say anything about absolute numbers; it only shows that a significantly lower share of firms covered by the CIS holds formal IP in the small and medium firm size categories than in the large firm category. This evidence for the UK is consistent with the available data for the US.

Balasubramanian and Sivadasan (2009) combine the NBER patent data with the US Business Register of the US Census Bureau to find that patent-owning firms are much larger than non-patenting firms (15-16 times so for output, value added and capital, and 10 times for employment). Also with regard to product and process innovations, large companies appear to be more active than small and medium-sized firms. There is an important caveat: given that firms report only a binary response, either to innovate or not, there is a size bias in firms' responses, i.e., the larger the company, the larger its likelihood of reporting an outcome variable =1. Regardless of this size bias, it is noteworthy that the difference in shares of product and process innovating firms across size categories is not as pronounced as it is with regard to patents and trademarks.

Figure 1: Firm size, innovation, and intellectual property



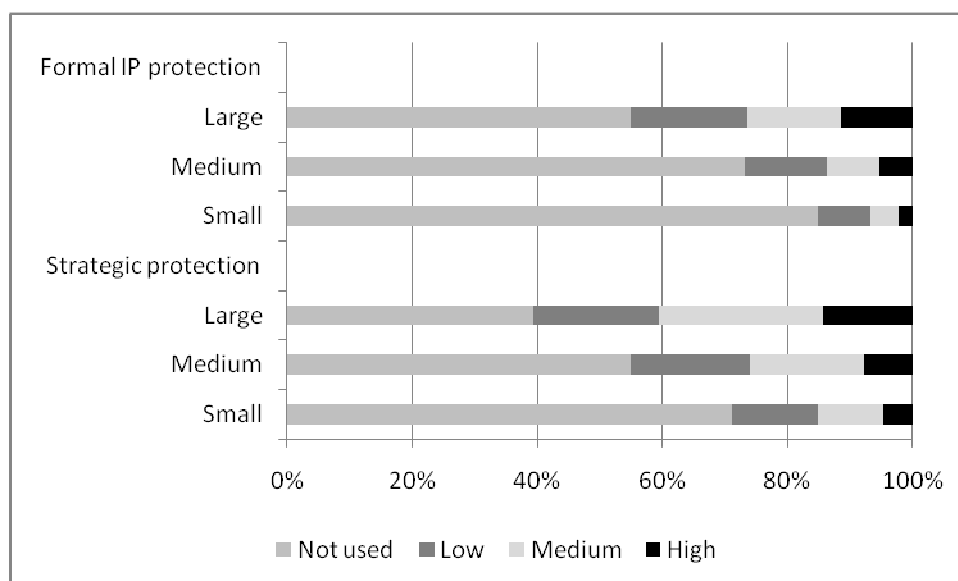
Source: UK ONS Community Innovation Surveys 3, 4, and 5 (for firm size definitions see text)

Existing survey evidence on the importance of patents for firms' strategies to appropriate returns to innovations has resulted, broadly conceived, in a rather negative picture regarding the value that firms attach to patents which may help explaining the extremely low numbers of patent holding firms shown in Figure 1. Seminal surveys among companies in the US by Levin et al. (1987) and Cohen et al. (2000) and data obtained from the Community Innovation Survey conducted across a number of European countries (Arundel, 2001) have found that firms regard secrecy and lead-time advantages as more important means to appropriate returns to innovation than patents. These studies also point to important inter-industry differences in firms' appropriation strategies. Patents are found to be more important in so-called discrete-technology industries, chemicals and pharmaceuticals. These surveys also find that patents are used to a considerable extent for strategic motives, to enhance bargaining power in litigation and cross-licensing agreements and enhance a

firm's reputation. Arundel (2001) finds smaller firms to rely more on secrecy as a protection mechanism than larger firms in Europe. The most comprehensive study of this kind that focuses on small, start-up companies, yields similar, albeit more favorable findings with regard to the importance of patents (Graham et al., 2010). The findings by Graham et al. suggest on the one hand that patents are an important means of appropriation for small firms and on the other, contrary to commonly-held beliefs, that small firms patent also for strategic motives. Hence, while patent propensities for a given innovation appear to differ between small and large companies, their motives to use IP are similar although the actual use of IP and its impact on firm performance may differ. Moreover, the available survey evidence (Giuri et al., 2007) suggests that small firms are much less likely to hold patents that are not 'worked', i.e., actively used but held as dormant property rights, which is what would be expected in light of the costs of maintaining IP in force.

Figure 2 also uses the UK CIS data described above to shed some light on firms' perceptions of the importance of formal IP rights versus 'strategic' mechanisms of protection such as secrecy, complexity of design or lead time. The figure shows that large firms regard formal IP in the form of patents and trademarks as much more important than small or medium-sized companies. However, the share of firms reporting the use of strategic protection mechanisms is much larger across the different size bands confirming the findings described in the preceding paragraph. Nevertheless, again large firms regard such mechanisms as considerably more important than smaller companies.

Figure 2: Firm size and the importance of intellectual property vs 'strategic' protection mechanisms



Source: UK ONS Community Innovation Surveys 3, 4, and 5 (for firm size definitions see text)

Note: Formal IP protection contains patents and trademarks; strategic protection contains lead time, complexity of design and secrecy.

In summary, there is considerable empirical evidence demonstrating the importance of small firms for innovation and its active use of the IP system to protect and exploit inventions. However, these

statistics should not be misinterpreted. There is huge heterogeneity among small firms and the share of innovative firms within the small firm category is tiny. The overwhelming share of small firms serves local niche markets, is not engaged in research creating breakthrough innovations and has little growth prospects (Shane, 2009; OECD, 2010) and does not use the IP system. However, there is also a group of small, highly innovative firms. While these small firms often do not have a formal R&D department, this does not automatically imply that small firms are generally less innovative than large firms (Acs and Audretsch, 1987a). A substantial share of small firms is highly specialized, research-intensive and often active in technologically new and fast developing areas. While some create drastically new products, services and processes, others are specialized in adapting existing technologies for specific niche markets. These innovative, small firms have enormous growth potential and have been shown to contribute to job creation and economic growth (Anyadike-Danes et al., 2010). Acs et al. (2008) show that in the US nearly 94% of so called 'high-impact' firms - firms with relatively fast revenue and employment growth - have less than 20 employees. Only 0.3% of high-impact firms in the US belong to the large firm category. This evidence points to the economic importance of innovative small firms motivating a closer look into their use of IP.

3. IP and firm size

This section discusses cross-cutting issues related to IP that affect all firms albeit to a different degree in function of firm size. The aim is to list the main issues that arise in a firm's IP management and to discuss how these challenges vary by firm size. The discussion focuses mostly on patents although it carries over to the different forms of registered IP. It should also be noted that firms may transition along their life cycle from one to size category to another which implies that the challenges firms face over time will change accordingly. At initial stages, firms are commonly smaller and more limited in scope. If they grow, usually also the range of business activities broadens. This generates the need to anticipate and adapt a firm's IP policy to these changes, although this is not discussed further in this chapter.

3.1 General issues

There is evidence that suggests that industry growth comes mostly from the expansion of the size of existing firms rather than from market entry (Rajan and Zingales, 1998). Therefore, the first question that we ask is: what is the role of IP in determining a firm's size?

Most firms are small at the moment when they enter the market; few firms enter the market as large companies. Acs and Audretsch (1989b) find new firms to be small in markets in which there are technological and growth opportunities as well as markets that are characterized by low R&D intensity and market concentration. Kumar et al. (1999) explore the determinants of firm size more generally for a cross-section of firms across 15 European countries. They find evidence for scale effects, i.e., firms in larger markets tend to be larger. Kumar et al. also find firms to be larger that operate in R&D-intensive industries. These authors also find some evidence that institutional development is negatively correlated with within-industry dispersion of firm size. This reflects a well known result that regulatory costs have disproportionate effect on small firms. Evidence suggests

that at a threshold of around 20 employees, regulatory costs per employee stabilize although the threshold differs by sector as for example business and transport services have been found to incur higher annual costs per employee than manufacturing (OECD, 2005). These findings suggest that there are some regularities in the determinants of firm size across industries and countries. Although the authors do not analyze the link between firm size and IP use, the evidence on R&D intensity suggests that firms need to be relatively large to be able to conduct innovative activities in the form of formal R&D. Moreover, Cohen and Klepper (1996) suggest that firm size also influences the type of innovation conducted by firms. The authors show for a set of US firms that larger companies undertake more process R&D than small firms (this applies also to the UK as shown in Figure 1).¹² Cohen and Klepper argue that larger companies are better able to appropriate the returns to innovation due to their larger output; hence they are able to afford to distribute the cost of process innovations across output than small firms. According to Cohen and Klepper (1996) this cost-spreading advantage is less pronounced for product innovations, as they can be licensed out and may generate fast output growth which makes initial firm size less important. There is evidence suggesting that product and process innovations are subject to different patenting propensities under the assumption that secrecy is easier to maintain for process innovations (Levin et al., 1987; Cohen et al., 2000), which implies that large and small firms are inherently characterized by differences in their patenting behavior.

The findings by Kumar et al. (1999) also suggest that firms tend to be smaller in the presence of financing constraints. In light of empirical evidence that firms are hampered in their innovative activities by financing constraints (Hall, 2002), this may suggest that the relationship between firm size and innovation is linked to firms' ability to finance the required long-term investment into research and development. Acs and Audretsch (1987b) find that large firms are more innovative in sectors that are capital and advertisement intensive as well as relatively more concentrated. Small firms are found to be more innovative in highly innovative industries which are characterized by the presence of a large share of large firms. Matthews et al. (2003) suggest that size maybe irrelevant for IP management in fast-moving high-tech sectors where small specialist firms maybe at an advantage. Hence, there appears to exist some influence of firm size on a firm's ability to innovate and thus to use IP.

At the same time, innovation and IP may also impact on firm size. Helmers and Rogers (2009b) assess directly the importance of patents for growth of new firms during the first five years following their market entry. They find patenting start-up companies to have an average growth advantage between 8 and 27 percent during the first five years of a firm's life, which suggests that firm growth and the use of IP is positively correlated. Balasubramanian and Sivadasan (2009) provide similar evidence for US firms which suggests that firms experience an increase in size following their first patent filing. Average firm size in an industry may also increase due to exit of smaller companies. With regard to IP management, an interesting question is whether IP plays any role in determining a firm's propensity to exit the market during the company's early years of existence. There is some evidence that patenting and trademarking firms have a substantially lower probability to exit the market within the first five years of their existence (Helmers and Rogers, 2010).

Another broad issue concerns competition between small and large firms within industries. Caves and Pugel (1980) suggest that small firms adopt specific innovation strategies to compete with large

firms. This is confirmed empirically by Acs and Audretsch (1988) who find some evidence that innovation by small firms within four-digit SIC industries increases with the employment share of large companies present in a given sector. Based on this evidence, Acs and Audretsch suggest that small firms have to innovate more to compete with large firms. This interpretation is corroborated by their finding that market concentration has a negative impact on innovation. Large and small firms may also choose to collaborate instead, for example in form of strategic alliances and joint ventures. This form of collaboration may be particularly interesting for a large company if it wishes to enter new markets and the small firm obtains access to the resources of the large company: the small firm provides ideas, entrepreneurial drive, speed at decision-making and flexibility and the large company capital, production facilities, marketing capacity, and a distribution network. Such large-firm small-firm strategic alliances are particularly frequent in industries subject to fast technological progress such as biotechnology (Forrest and Martin, 1992). There is a third channel for small-firm large-firm interaction: small firms may serve as suppliers to large companies. In such a relationship, the large company may require the small company's assurance that its products are founded on solid intellectual property. This will provide strong incentives for smaller firms to adopt an own IP strategy, possibly with assistance of the large company that may be willing to share its expertise in IP management (Matthews et al., 2003).

3.2 Costs and Benefits of Patents across Firm Size Categories

A firm's decision of how to protect its inventions is closely linked to its strategy to commercially exploit its inventions. An invention on its own yields little gain for a company. It needs to be transformed into commercializable products and processes which then transform existing or create new markets. Firms may choose to exploit innovations themselves, use them to create a spin-off company, set up a joint venture in form of a separate (independent) business entity, or even determine ex ante that the innovation is sold on the market for technology. As explained throughout this book, IP can play a role in all of these different forms of commercial exploitation. Alternatively, firms may regard secrecy as a more appropriate mechanism to protect and exploit knowledge. Other appropriation mechanisms include unregistered IP, lead-time advantages, spatial differentiation, the use of niche markets and marketing. The decision between the different mechanisms to appropriate returns to an innovation will depend on the relative costs and benefits. With regard to firm size, in principle, there is no reason why IP and different forms of IP would be more appropriate for firms of different size. But the costs/benefit tradeoff may make IP more attractive to firms of different size categories. Moreover, the resources available to firms obviously differ with firm size. This implies that if a firm's ability to make an informed decision on how to protect an invention and to achieve and maintain effective protection is a function of available resources, small firms may be disadvantaged relative to resource-abundant large companies. The distributions shown in Figures 1 and 2 suggest that at least some of these mechanisms are at play.

3.2.1 IP-related information

Firms with inventions that can be protected by formal IP may not seek to obtain IP simply because they are not aware, for example, of the patentability of the invention or lack knowledge about the administrative procedures required to obtain IP protection. The necessary knowledge includes also more technical expertise such as the ability to conduct prior art searches in preparation of a patent application. The knowledge and familiarity with the IP system is likely to be a function of the resources available to a firm, which means that smaller firms might be at a disadvantage in this

respect. The OECD suggests that 'SMEs lack a good working understanding of the IP rights system and consequently under exploit current forms of IP protection' (2005: 10). IP awareness also requires the effective dissemination of relevant information within the firm. Such information can be basic, for example informing employees how to conduct their research and its dissemination without jeopardizing the firm's ability to obtain a patent right. This means that a firm has to put in place mechanisms that guarantee the continuous education and training of staff across different departments. For smaller firms without specialized IP staff, this task might be hard to achieve internally. While in principle firms have the possibility to purchase external expertise, Hughes and Mina (2010) provide survey evidence for small US and UK firms (10-99 employees) which suggests that only a tiny share of small firms purchases external IP advice and expertise and over 40% of small firms in both countries report to never engage in the purchase of such services.

The lack of knowledge and awareness of the IP system may also lead smaller firms to benefit less from the technical information made available in patent documents.¹³ Arundel and Steinmueller (1998) discuss survey evidence obtained from Dutch SMEs which shows that smaller firms rely on average very little on patent documents as a source of information both in terms of basis for own innovations and to monitor competitors. Trade fairs, conferences and journal publications were considered more useful as they were seen to provide cheaper and more easily accessible technical information. These findings might still be of relevance despite the substantial improvements in the availability of free-of-charge patent information online since the time when Arundel and Steinmueller conducted their survey because SMEs indicated in the survey that the main obstacles are time and required expertise to conduct useful patent database searches. These are constraints that mostly likely still apply. More recent survey evidence on UK SMEs by Macdonald and Lefang (2003) suggests that the main motivation for SMEs to conduct patent searches is of legal character rather than as knowledge input for own innovation: to verify prior art in the preparation of a patent application or to investigate infringements by third parties.

3.2.2 The decision to use IP

If firms possess the required information on the IP system, ideally firms make a conscious decision of whether to seek IP for an invention based on whether perceived benefits outweigh perceived costs – provided the invention can be protected by formal IP rights from a legal point of view. Once firms have obtained IP, they may still choose to re-assign it to third parties instead of 'working' the IP themselves. In practice, firms usually employ a mix of the different ways of protecting and exploiting inventions although the composition of different protection mechanisms depends on firm size.¹⁴

If a firm has an invention, it has several options. It can make the invention freely available to third parties and even disseminate it actively. There may exist compelling strategic motives for this, if for example firms profit from selling complementary assets or services. This may be an attractive business strategy for early-stage companies that aim to expand the applicability of their technologies. Swanger and Maidique (1988: 298) report that when Apple Computer Inc. was still a small company in 1977, it intentionally presented its Apple II with a complete description of the technical data to enable independent users to develop hardware and software for the Apple II. Such generous disclosure was an unusual move in an industry characterized by high level of secrecy and absence of patenting. Firms may also attempt to mold the appropriability regime governing technologies or industries by making inventions freely accessible to third parties.¹⁵ Defensive

publications are a widely used mechanism to disclose technological information. In contrast to secrecy, defensive publications still guarantee a firm's freedom-to-operate and in practice, secrecy can often be maintained as the information that needs to be revealed can be restricted or substantially disguised.¹⁶ Henkel and Pangerl (2008) suggest that defensive publishing is widely used by firms and that firms choose defensive publications over patents to avoid the costs associated with patenting or in situations in which it is unclear whether the innovation is patentable or its expected value low. Baker and Mezzetti (2005), in contrast, argue that defensive publications are used strategically by firms to influence the state of prior art relevant to competitors' patent applications. Disclosing previously unknown information to the public can raise the inventive step threshold, thereby jeopardizing competitors' patent applications. In any case, the evidence suggests that firms use defensive publications in combination with secrecy and patenting. There is hardly any empirical evidence on differences between small and large firms in their willingness to grant third parties free access to knowledge or even engage in its active dissemination. It is nevertheless remarkable, that mostly large patentees engage in the selective dissemination of knowledge, with IBM being one of the driving forces of the open source movement in the software industry and actively promoting royalty-free access to patented technologies also in other technological areas.¹⁷ Firms may also choose to give away their patents by either abandoning or donating them. While abandoning allows firms to save on maintenance costs,¹⁸ patent donations may be, for example in the US, tax deductible.¹⁹

Firms may also rely on non-registered IP rights such as trade secrets, copyright, unregistered design rights, confidentiality and secrecy clauses in employment and customer/supplier contracts. Trade secrets and confidentiality agreements have the objective to maintain inventions secret whereas unregistered IP such as design rights rely on the possibility to deny third parties the use of the protected invention. Secrecy and unregistered IP rights also involve considerable direct and indirect financial costs as well as uncertainty. Moreover, they require a considerable amount of managerial effort and monitoring of employees. This also involves the establishment of an internal rule-set that regulates the management of knowledge within the company. For example, if researchers publish in professional and academic journals, this might cause knowledge leakage and the published information forms part of prior art, potentially preventing a firm's eventual ability to patent the corresponding invention. Hence, firms less able to implement such in-house rule sets may prefer to release technical information exclusively through the standardized information contained for example in patent documents, which can be controlled by a firm's management. Other issues involve embodied knowledge, i.e., secrecy is at risk if researchers and employees move between competitors. Strategies that can be pursued to protect a company's knowledge involve the fragmentation of knowledge. Zhao (2006), for example, provides evidence that US MNEs conduct R&D in countries with weak IPR protection when the resulting innovation is integrated into larger global R&D projects of the holding company. In this case, the value of an innovation emerges only when it is integrated and complemented with knowledge and resources held by the company abroad. The famous example of Steve Jobs visiting Xerox's Palo Alto research center in 1979 and thereby learning about Xerox's graphical user interface also shows that physical access to research facilities has to be carefully monitored. With regard to secrecy and unregistered IP rights, larger firms are rather able to afford specialized personnel that oversee the knowledge management within the company. At the same time, knowledge leakage is more likely to occur in large

companies. Hence, on balance it is unclear whether secrecy is more easily maintained in small or large companies. From an empirical point of view, Arundel (2001) finds for his analysis of the CIS 1993 data covering around 2,850 R&D performing firms that firms systematically regard secrecy as a more important way to protect their innovations than patenting. Arundel also finds that the importance of secrecy for product innovations decreases in firm size, suggesting that smaller firms may rely more on secrecy as a way of appropriating returns to innovation.

If firms seek formal IP protection, a range of often complementary motivations plays a role and we focus here on those for which there exist differences across firms of different size. An important motivation for firms to seek IP is to use it in a defensive or offensive strategic way. Offensive means that a firm uses IP to block competitors from using a technology, trademark or design. This may increase the costs for competitors, the time needed to enter a market because the competitor needs to adapt products, invent around the protected technology, pay for a license or may even foreclose the competitor. The defensive use aims at ensuring freedom-to-operate by preventing competitors from blocking the company itself. Such strategic motives have been commonly ascribed only to larger firms. However, Graham et al. (2010) provide survey-based evidence on start-up companies in the US suggesting that it is equally important for small high-tech companies in the bio-tech industry.

IP may also be used as bargaining power in cross-licensing agreements. Particularly in industries characterized by cobwebs of patent rights, firms rely on cross-licensing to ensure freedom-to-operate. Here, small firms are at an obvious disadvantage as their IP portfolio is necessarily smaller than that of large firms. There is some survey-based evidence supporting the more widespread prevalence of cross-licensing among large firms in Europe as well as the importance of cross-licensing in sectors such as electronics and semi-conductors (Gambardella et al., 2007). This may pose a serious obstacle to small firms entering and operating in such markets. A related motivation to obtain IP is cooperation between firms. Firms may engage in joint R&D which can result in joint IP. While there is some sparse evidence on joint patenting more generally (Hagedoorn, 2003; Kim and Song, 2007), so far, there is no empirical evidence on firm size differences in joint patenting.

Firms may also obtain patents in the objective to generate licensing income. This is a strategy that is more likely to suit the business model of smaller companies, as it is a viable strategy if the firm itself has no plan to commercialize the invention and produce the resulting products itself but to specialize in research and development.²⁰ Even if firms commercialize the invention themselves, in the case of small firms with small market shares, the gain in revenue from licensing income is more likely to outweigh the loss in profits due to competition as a consequence of licensing (Arora and Fosfuri, 2003). Moreover, larger firms possess complementary assets making the own exploitation of an invention more likely (Teece, 1986). Gambardella et al. (2007) confirm empirically the importance of licensing for smaller companies in the PatVal-EU inventor survey of over 9000 EPO patents between 1993 and 1998. However, there are still strong forces dampening the interest of smaller firms in a 'licensing business model'. First, smaller companies may find it more difficult to determine the total stream of future expected profits from royalty payments since there is considerable uncertainty attached to the value of innovations (Lanjouw et al., 1998). In addition, expertise and experience in drawing up licensing contracts may constitute an important barrier to successful licensing. Given that smaller firms are more likely to lack such expertise and experience, they may fail to license out despite their greater willingness to engage in licensing out of patents. The limited

available empirical evidence on the issue for the US and Canada (Razgaitis, 2004) does not support this hypothesis. Small and large companies seem to face similar constraints in licensing although small firms appear to have more difficulties in finding a potential licensee whereas large firms report more difficulties in successfully concluding licensing negotiations which may be due to more rigid and demanding negotiation. In general, it appears that the patents licensed by large firms are mostly patents that are not worked and protect technologies more remote from a firm's core business activities or in geographical markets where the firm itself is not active.

Patents can also be used to effectively determine technology/industry standards which are particularly relevant in information technology. Patents can play an important role in providing access to standards. In particular, before a standard is set, a patent may not severely restrict other actors in their freedom-to-operate since there are commonly a number of competing technologies. However, once the standard is defined, the essential patents become indispensable in a firm's ability to conform with the standard, conferring substantial market power to the patent holder. This however, is only feasible for large companies and can thus have a negative impact on the ability of small firms to enter and operate in such markets. Standard setting through patents can also create powerful hold-up problems both through strategic non-disclosure of relevant patents before a standard is set and by forcing the licensing terms on users for standard defining patents that have few or no substitutes (Farrell et al., 2007).

IP can also be useful to shape a company's corporate image. IP is widely perceived as a sign of a firm's ability to innovate. It can therefore be used to signal the quality of an invention to potential investors and customers and create a generally improved public image by conveying technological leadership through large patent portfolios. Firms can therefore employ IP to influence customers' and financiers' perception. In particular the marketing aspect may be attractive to large companies as illustrated at the example of the German car manufacturer Audi that launched a multi-million dollar advertising campaign in 2006 claiming that 'To date, NASA has filed 6509 patents. In developing the A6, Audi filed 9621.', suggesting technological leadership through the total number of patent filings. Small firms, in particular start-ups, may rely on this strategy mostly to impress potential external investors in order to obtain essential external financing. The 'prestige' argument has to be separated from the possibility for IP to increase the salvage value of a company and hence to reduce the risk an investor bears. While IP as collateral is particularly useful for start-up and small companies, also large companies routinely assign patent rights to banks as collateral.

Finally, Granstrand (1999) suggests that patents can also serve as an internal measure of research output. Since IP is easily countable and conforms to certain legal minimum requirements establishing the innovative step and novelty of the invention, patents represent a simple way to assess the innovative activity of researchers. This appears to be more useful in larger companies where it is more difficult to oversee the innovative activities of staff.

The costs associated with patenting concern primarily the direct and indirect financial costs associated with it and the required disclosure of information. Applying for a patent requires direct and indirect financial expenditures and a patent may not necessarily be granted. To keep the patent in force, maintenance fees have to be paid to each patent office which has validated the patent. The OECD (2009) estimates that in 2003, on average, obtaining a patent for the EPO costs slightly more

than EUR 30,000, through the PCT route nearly EUR 47,000, the USPTO around EUR 10,000, and EUR 5,500 for the JPO. Second, a patent also requires disclosure of technical information in the patent application which may be useful to competitors. In particular smaller firms may consider the loss in information to be disproportionate to the gain provided by the patent right since a large part of their business model may be based on a single invention. Third, a patent is only valuable if it can be enforced. Effective enforcement first of all requires validity of the patent right. Second it requires active monitoring of potential infringement and the ability to afford legal action in case infringement is detected. We discuss issues related to patent litigation and firm size in more detail in Section 3.3. below.

Given the costs and benefits of using formal IP protection, small firms may face a trade-off as they might be able to afford either the costly protection of existing knowledge or additional the investment in the creation of new knowledge which requires as difficult managerial decision. Such a trade-off is much less likely to arise for large companies.

3.2.3 IP Management

As illustrated throughout this book, IP requires active strategic management. Not only patents, which often protect complex technologies, require active management, but also other forms of IP, such as trademarks and registered designs. Building and promoting brands requires a strategic perspective to create sharp distinctiveness that characterizes valuable trademarks; active maintenance of a brand is even a legal requirement to obtain trademark protection. Given the various options described above to protect inventions, active IP management has great potential to influence a firm's strategic position in the market. Active IP management requires effort not only at the time of filing for IP protection, but also over time after a patent has been granted or a trademark registered. Patents have to be maintained in force, monitored and if deemed useful, follow-on patents need to be filed. In some circumstances, patents may only be useful when other patents are held by the same firm with overlapping rights, for example, a firm can have a patent on a basic innovation and then protect applications through additional patents. The design of the patent system also allows for a range of strategies, such as anticipating publication and examination or delaying it, which may have strategic value to firms in specific circumstances. The management of such strategic IP activity requires not only expertise and experience, but also complex managerial processes within companies.

Firms may choose to take out a single patent on the core invention, or file directly for a number of related patents that protect not only the innovation but also potential applications and related processes or protect these through other forms of IP. The decision is of strategic nature and depends on the firm's own competitive position and that of its competitors. Hence, IP management requires planning beyond operative processes which would simply ensure that the procedure for filing a patent application is properly followed. In practice, certain aspects of a firm's business are protected by different mechanisms and often multiple forms of IP are used to protect different aspects of single inventions. For example, a company's core technologies are often kept secret or patented. At the USPTO, also software created by a company can be patented. Alternatively it can be protected by copyright or secrecy. Also packaging may be protected by patents, designs and marketing. Establishing the appropriate coverage employing the different available strategic protection mechanisms and IP rights over time is a challenging task.

These processes can be managed in various ways. Firms can for example manage IP on an ad hoc basis in a responsive manner. For example, if a firm is accused of infringement, it will have to analyze its IP position relative to the firm that claims infringement. Similarly, a firm may choose to clear its patent position before engaging in new research only because external investors require it. Licensing may also be dealt with in an ad hoc manner, for example licenses may be granted only when third parties approach the firm. Alternatively, licensing can take a central role in a firm's IP strategy. Licensing-in of innovations can strengthen and speed up in-house development and licensing-out may represent a source of significant income as discussed above. Firms may alternatively establish a corporate IP strategy driven by legal concerns and/or strategic management concerns. This would involve the continuous review of a firm's own patenting position both from a legal and strategic point of view. The gathering of information on competitors' patenting and technology positions is of equal importance. This information can for example be obtained from publicly available and (mostly) free-of-charge patent information, although the collection and processing (including translation) of the information requires substantial expertise and time. This may motivate firms to outsource its IP management to specialized service suppliers. In any case, if a company decides to establish a formal corporate IP strategy, IP plays a central role also in the overall business strategy and the definition of new research projects. Deciding on the most appropriate form of IP for a given invention and managing the corresponding managerial processes as well as the complete IP portfolio of a company is a complex task. It is easy to see that larger firms are rather able to afford specialized personnel to develop and administer an IP strategy. Specialized staff is required due to the complexity of the IP system which requires substantial expertise and experience to take optimally advantage of the strategic opportunities it offers. Small firms, in contrast, are much more resource constrained, both in terms of staff time, expertise and monetary resources available for IP management and therefore may even ignore the managerial challenges active IP management poses.

3.2.4 Organization of IP Management

If a firm has decided to use (non-)registered IP, its management, the collection and processing of related information has to be organized within the company or a decision has to be taken to outsource the management of IP. If it is managed internally, somebody has to apply for IP, devise the appropriate protection strategy for (non-)registered IP and actively manage the existing IP portfolio. The managerial tasks include the identification of inventions, an evaluation of whether they meet the legal requirements for IP and the decision whether to seek formal IP or to chose alternative protection mechanisms. This also involves the gathering of intelligence on competitors' technological positions and IP strategies, information on oppositions to patent applications by third parties and the handling of infringement by third parties or the company itself. The organizational structure also needs to be designed in a way to regulate the interplay of R&D, commercialization and IP protection. There are several ways in which these tasks can be organized and this is an area where firm size commonly makes an enormous difference. Large firms often have specialized organizational units, whereas smaller firms often rely on ad hoc solutions. Small firms often have no specific arrangements other than a technical manager or engineer that is assigned inter alia responsibility for IP. However, this person usually needs to rely on the legal expertise of outside patent attorneys which can be very costly for smaller firms. Alternatively, firms may have an in-house patent specialist with sufficient legal and technical expertise to assume responsibility for IP management. Larger companies, in contrast, often have a centralized IP department located at the corporate headquarter

and possibly also smaller IP units in subsidiaries. The IP department is staffed with specialist IP managers that deal with various IP-related activities, coordinate protection and commercialization strategies with the R&D department, manage licensing activities (although this can be managed in a separate business unit), gather intelligence on the company's own and competitors IP position, and take care of legal disputes. Hence, such centralized departments assume most of the IP related tasks in-house; only when foreign patent agents are needed, tasks are outsourced. However, most of these tasks do not generate income, which implies that an IP department is a cost center and costs have to be distributed across other business units, which explains why only larger technology-intensive firms are able to afford such an organizational structure. Granstrand (1999) provides data on large Japanese companies that show the share of patent employees in a firm's total labor force. He finds IP specialists to employment ratios between 0.10% (330 specialists out of 324,292 employees in the case of Hitachi Ltd) and 0.56% (350 specialists out of 62,700 employees in the case of Canon Group). Granstrand also finds important differences across industries. Companies in the electrical industry employ on average over 200 persons that are occupied more than half-time with IP issues, whereas the chemical industry employs only 40 people. Most of these employees are engineers and located at the corporate headquarter. While larger firms are rather able to afford specialized IP departments, they may also be more likely to face coordination issues across business divisions and potential conflicts of competency. Moreover, larger firms usually also face more complex situations involving IP distributed across subsidiaries, joint ventures with third parties that result in joint IP, acquisitions and mergers of businesses and IP, and spin-offs.

3.3. Patent Disputes and Litigation

In an ideal situation, a firm proceeds as follows independently of firm size: the firm decides to design a new product or process; it sketches out the technological requirements of the new project. Given these requirements, the firm conducts a prior art search to determine relevant prior art that the new technology might require and/or infringe. If such prior art is found, the firm verifies the validity of the patent claim. If it decides that the patent is most likely to be upheld in court, it has the options to either modify its project design to account for the constraints imposed by prior art, it seeks a license agreement with the patent holder, or ignores the existing IP right and proceeds with the project without modifications.

If a firm finds itself blocked by an existing IPR, the firm has a number of options. It could simply ignore the existence of the patent. In fact, Lemley (2008) suggests that firms in the IT and biotech industry ignore existing patent rights on purpose to avoid willful infringement and academic researchers in these fields execute their research without conducting prior art searches. Supportive of this view, Cockburn and Henderson (2003) provide survey evidence collected among company IP managers that shows that only a third of respondents conduct a prior art search before starting new R&D or product development. Alternatively, a firm can attempt to invalidate a patent before court. At the EPO, for example, there exists the possibility to oppose a patent within nine months after a patent was granted. Oppositions are administrative procedures and thus are dealt with directly at the EPO and do not involve national courts. Other strategic options include the possibility to invent around an existing patent, usually by moderately re-designing the original innovation. Firms may also attempt to license the blocking patent or to acquire it. This option is more realistic if the firm that holds the blocking patent is not a direct competitor and does not regard the blocking patent as

essential to its core business. The worst case option is to abandon a research project or even to stop producing or selling the product infringing the blocking patent if none of the other options is successful. A firm may also behave strategically by exploiting the possible deterring effect its own patent portfolio may have: a large portfolio may lower the probability of ending up in court as it can be used to counter-sue the third party. In this respect, small firms are simultaneously at a disadvantage and advantage since on the one hand they do not possess large patent portfolios to deter lawsuits, but on the other, they often do not produce and may thus be less vulnerable to infringement and the payment of damages. Owners of infringed rights may choose litigation for a number of motives (Bessen and Meurer, 2005). Most importantly, they can seek to exclude competitors from using a technology. Alternatively, they can force competitors to acquire a license or directly the patent right. A law suit also provides the possibility to collect settlement payments, which could weaken a competing firm. Litigation may also be used for more strategic motives, such as dominant incumbent firms threatening to sue smaller actual or potential competitors to prevent market entry or to obtain detailed technical information on a competitor's innovations if the court grants the right to inspect the competitor's products. Still, in order to take legal action, firms have to (a) observe infringement, (b) be able to identify the infringer, and (c) be able to afford litigation. Patent litigation is extremely costly, which may explain why existing research as well as anecdotal evidence suggests that only a tiny share of patent disputes ends up in court (Ball and Kesan, 2009; Greenhalgh et al., 2010). In particular smaller firms may not be able to afford such costly litigation and thus avoid litigation altogether.

As already pointed out above, IP management with respect to legal disputes requires the structured compilation of intelligence on competitors' IP portfolios and innovative activities. Firms need to be aware of innovative activities of competitors that may lead to patents that could influence a firm's own freedom-to-operate and might lead to infringement suits in the future. To draw a complete picture of a competitor's position, information on licensing, existing patents, defensive publications, other publications for example in professional journals are needed (which are often published in languages other than English). Firms may even choose to reverse engineer competitor's products to complete their understanding of the technologies employed by competitors. The collection and processing of such complex information requires resources that small firms may not possess.

If a firm detects infringement of an IP right or is accused of alleged infringement, litigation may take place. Litigation may be pursued in an active, reactive, or even passive way. The objectives that firms pursue may also differ. Few firms may not be particularly motivated to end up in court, as the costs involved in litigation are enormous. Hence, firms may be interested in deterring infringement or further legal action in case they are accused of infringement. If deterrence does not work, firms may attempt more formal arbitration/settlement procedures. If all options fail, firms will end up in court and may have to pursue the case up to a final judgement. The procedure is similar if a company finds a third party to infringe the company's IPRs. The firm will initially attempt to solve the dispute on a bilateral basis, and only if the written warning is rejected or ignored, a firm may decide to proceed to court or to ignore infringement to avoid an escalation of costs. In any way, the option of settling a dispute in court needs to be carefully considered, as it involves large direct financial costs and can also involve indirect costs, such as a drop in stock prices in the case of large companies or loss of venture funding in the case of start-up companies. Bessen and Meurer (2008), for example, find that

alleged infringers lose half a percentage point of their stock market value as a consequence of the filing of the law suit which is a substantial economic effect.

The overwhelming share of the literature on IP litigation focuses on patents. However, trademarks also represent an emerging area of litigation. In any case, all the available evidence suggests that small firms are at a substantial disadvantage in this area which may have an enormous impact on the cost/benefit relation associated with formal IP for smaller companies. Bessen and Meurer (2005) suggest that the value of patenting stems entirely from the threat of litigation rather than actual legal proceedings which is confirmed empirically for the US by Lanjouw and Schankerman (2004). This means that small firms may be unable to effectively participate in the system as they may be unable to credibly threaten infringing third parties with legal action.

In particular, disputes may also arise between firms of different size, i.e., for example a lawsuit with a large firm plaintiff and a small firm defendant. Such asymmetries are likely to impact on the litigating parties' behaviour as this involves not only asymmetries in resources and bargaining power but potentially also in the value the different parties attach to the litigated patent. If two small firms litigate, both firms are similarly resource constrained and it is difficult to settle the dispute through cross-licensing agreements because both parties have small patent portfolios. At the same time, potential for damages is similarly low, but firms may desperately depend on the validity of the patent right. This situation is very different from a situation in which the plaintiff is a large company and the defendant small. The plaintiff can put the smaller defendant under pressure as it will be able to invest more resources into the lawsuit and to carry it out for a prolonged period of time, which may be financially prohibitive for the small firm. If the plaintiff is small and the defendant large, however, the small firm may be able to raise funding for its lawsuit as the potential for damages is large. Contrary to the case where both parties are large firms, the potential for settlement is small if the plaintiff is a small company as cross-licensing opportunities may not exist. Hence, litigation behaviour does not only depend on a firm's own size, but also on the opponent firm's size and resources.

Kesan and Ball (2009) investigate this using data on the litigation behaviour of firms in the US. They have data on all outcomes of court cases including settlements. They find that only slightly less than 4% of cases are decided through judgements, whereas 70% settle. Surprisingly, for their data they find that around half of all defendants and plaintiffs are small firms. The substantial share of small firms among litigating firms has also been found for Germany by Cremers (2007). Kesan and Ball (2009) find small firms also to be most likely to litigate with another small firm. Nevertheless, approximately 20% of small firms sue large infringers with annual sales over US\$ 500 million. Kesan and Ball (2009) find that asymmetries in the size of the litigating parties has an impact on their litigation behaviour as small firms are most likely to pursue a court judgement when they sue large firms. The authors conclude that small firms are able to aggressively take action against large companies under the prospect of the award of large damages. Another motivation for small firms to behave aggressively is the lack of alternative settlement opportunities for example in form of cross-licensing agreements and the fact that they are defending IP that is particularly valuable to their business. This finding, however, contrasts with Cremers (2009), who finds for Germany that the timing of the settlement is not influenced by the absolute or relative size of the litigating parties. Lanjouw and Schankerman (2004) look directly at the question of whether small firms find

themselves at a disadvantage when it comes to patent litigation. They find small firms (size is measured by employment) with smaller patent portfolios face a much higher probability of being involved in patent litigation. They also find litigation to be less frequent in technology areas that are characterized by the presence of few firms. Since fewer firms increase the likelihood of repeated interaction among players in a market, Lanjouw and Schankerman interpret this as evidence in favor of the litigation-reducing effect of repeated interaction. Their findings, therefore, suggest that small firms are at disadvantage vis-à-vis larger firms. The conclusions drawn by Lanjouw and Schankerman (2004) echo similar findings by Lerner (1995). Lerner provides evidence suggesting that patent litigation may serve anti-competitive purposes by large companies in the bio-tech sector (company size is measured as paid-in-equity). He shows for his sample of 419 bio-tech firms that smaller firms avoid patenting in subclasses in which large companies have patented. Moreover, for those smaller firms that patent in a subclass in which rivals have patented, the last rival's patent in that subclass is further in the past than in the case of larger firms. Lerner interprets his findings from a litigation cost perspective: firms for which litigation is costly avoid potential conflict with firms for which litigation is less costly. Hence, the available evidence points towards smaller firms being at a disadvantage when it comes to patent litigation, although this statement has to be qualified in light of the findings by Kesan and Ball (2009) which suggest that small firms are able to take on larger companies if there are reasonable chances to extract large damages from the larger firms.

3.5. Internationalization and Business Groups

There has been a widely-discussed increase in the internationalization of research and development over the past 20 years (Narula and Zanfei, 2005). The drivers for this development are manifold including the economic and political opening of a large number of countries, increased FDI, increased opportunities for collaboration and research joint ventures, etc. Archibugi and Iammarino (1999) classify the different patterns as follows: (a) international exploitation of innovation produced on a national basis which covers exports, as well as licensing and assignment of IP; (b) global generation of innovations by multinational enterprises which involves innovative activities in several countries and usually some form of FDI; and (c) global technological collaborations which involve research joint ventures and research collaborations between firms but also with public research institutions and universities. The international exploitation of innovation and international collaboration are open to small firms whereas the international generation of innovation is limited to multinational companies, which usually are large enterprises. In recent years, there has been an increase in the international exploitation of innovation by smaller companies. These firms often rely on product differentiation and superior product quality to compete in international markets, often occupying niche markets that are less contested by large firms (Cavusgil and Knight, 2009). SMEs that pursue such international business strategies founded on differentiated technologically cutting-edge products have a particular interest in protecting their competitive advantages through IP. Kitching and Blackburn (2003: 24) provide qualitative survey evidence demonstrating the different strategies required depending on a firm's degree of internationalization: they quote an anonymous entrepreneur saying "If the world is your customer then you want to protect your ideas to make sure you get the maximum return from it. But if the customer is a very limited number of people then it is not worth all the hassle. Just get on and do it." Hence, international exploitation implies that firms may shift towards an IP-based business strategy and even obtain IP protection abroad. Indeed, the number of patents held by foreigners has increased substantially over the past two decades. The

strengthening of IP rights due to TRIPS in a number of mostly developing countries is believed to have contributed to this development (Lerner, 2002). Nevertheless, analyzing patent documents, Harhoff and Thoma (2010) note a heavy geographical concentration of inventors with about 80% of all inventors listed on EPO and PCT patent documents located in only five countries, the US, Japan, Germany, France and the UK. At the same time, Harhoff and Thoma (2010) also point out substantial differences across countries in terms of inventor locations: whereas more than 85% of inventors listed in patent applications held by Japanese and Korean assignees are also located in Japan and Korea respectively, less than 20% of inventors of Dutch applicants are located in the Netherlands.

Internationalization has also important implications for all of the issues discussed so far. Firms that operate, or plan to operate internationally need to consider international protection of their inventions and whether their products infringe existing IP rights abroad. Additional issues emerge when products have to be adapted to local needs and standards. This means that IP management also involves decisions about the geographical coverage of protection which has important implications for a company's IP filing strategy. For example, if international protection is required, filing patents through the EPC or PCT routes becomes relevant. However, protection in multiple jurisdictions is very costly, where a large share of these costs is accounted for by translation costs and other administrative fees. When the services of foreign patent agents are required, the associated costs will be substantial. This also concerns patent litigation as enforcing patent rights abroad may be extremely costly and risky. Despite these constraints affecting disproportionately smaller firms, recent evidence for US companies in the field of nanotechnology suggests that small companies hold a large (nearly 40%) and increasing share in 'international' (i.e., PCT) patents (Fernández-Ribas, 2010). The evidence also suggests that smaller firms seek patent protection in few countries compared to large firms. The number of PCT applications by smaller companies designating Germany, Australia and Canada even outstrips those of large companies. In particular the fact that small firms seek protection directly in Germany and not via the EPO route suggests that smaller firms are more selective than large companies. In contrast, in emerging markets, such as China and Russia, large companies hold considerably more PCT patents than smaller firms. One of the main motivations for companies to internationalize their business is not only to increase their sales but also to source knowledge abroad. Griffith et al. (2006) provide evidence for UK firms becoming more productive by sourcing knowledge through their subsidiaries in the US. They show that UK firms that have a larger proportion of their business activities located in the US benefitted more in terms of productivity growth from growth in R&D activities in the US during the 1990s. This suggests that multinational businesses benefit in terms of their performance from their ability to source knowledge world-wide. This may give larger companies a competitive edge as they are rather able to organize their business internationally and afford the necessary investments.

International companies are often organized as business groups which are sets of legally independent companies that are tied together through legal arrangements and belong to the same ultimate owner.²¹ Firms in business groups potentially enjoy a number of advantages that make them more innovative and more likely to file for registered IP: (a) Firms in business groups may rely on group-internal financing. This is particularly important with regard to innovation as firms often face difficulties in obtaining external financing for innovative projects. (b) Firms within business groups may more easily collaborate, and share knowledge openly; this includes both intentional knowledge transfer and unintentional knowledge spillovers. Resource-sharing may also concern

employees and their expertise which can be transferred and borrowed within the group. Business groups are also able to establish an internal market for technology, i.e., technology in both tacit and formalized forms can be transferred and traded within the group more easily than outside. (c) Business groups are commonly in a range of diverse business activities. Diversification of business provides insurance against the uncertainties involved in the innovation process and thus contributes to more investment in research and development. On the other hand, business groups may also stifle innovation if their structure is bureaucratic and hierarchical. Innovation may also be delayed or not undertaken if the so-called business stealing effect applies within business groups, i.e., when a firm has to replace its own product on the market in order to innovate which implies the gain from innovation equals only the difference between income from the innovation and the income stream based on the current innovation (Arrow, 1962).

The existing empirical literature suggests that group membership indeed facilitates innovation. Belenzon and Berkovitz (2010) find for a set of large European companies that firms that are part of business groups patent considerably more than stand-alone companies. Belenzon and Berkovitz suggest that this is due to the firms' ability to draw on internal financing and to diversify their business activities. The available empirical evidence also suggests that business groups are more prevalent in R&D intensive sectors, which indicates that group formation is endogenous with firms responding to market characteristics by forming groups to overcome constraints (Belenzon and Berkovitz, 2010; Cainelli et al., 2006). There may also be interactions between group membership and the institutional set-up in which firms operate. Chang et al. (2006) find a positive correlation between business group affiliation and a firm's patent counts for Korean firms in the 1990s. In contrast, the authors do not find such a statistically significant association for Taiwanese firms, which the authors interpret as evidence that business groups compensate the lack of appropriate institutions required for innovation, because according to the authors, Taiwan offered a better institutional set-up for firms to conduct innovative activities than Korea. In addition, Chang et al. (2006) suggest that firms within business groups in Korea benefit more from resource sharing than firms in Taiwan due to a more centralized governance style in Korean Chaebols. The authors also find that the business group advantage declines over time as the institutional framework in Korea improved. These findings thus suggest that small stand-alone companies are particularly disadvantaged in countries with a weak institutional and business environment.

4. Conclusion

This chapter provides an overview of the available empirical evidence on differences in terms of innovation and IP use across firm size categories. The empirical evidence suggests that small firms use the IP system in absolute terms to a similar degree as large firms, although this only applies to a small fraction of the population of small companies. There appear to exist structural differences in the type of invention carried out by firms of different sizes and hence in their corresponding patenting propensities. However, the fundamental difference between small and large firms is the availability of resources with regard to all aspects of a business. This implies several constraints that small firms face in their IP management relative to large companies:

- First, small firms appear to be disadvantaged with regard to IP information. Small firms may lack expertise necessary to use the IP system and may fail to sufficiently exploit the technical information made available in patent documents. For this reason, there already exist a number of policies to assist firms in acquiring and updating the necessary information. For example there are large-scale national programmes targeted at the dissemination of IP related knowledge, as for example the Brazilian IP Program for Industrial Innovation.²²It will be interesting to evaluate the impact of such programmes on small firms' use of IP.
- Second, IP rights confer (strategic) value to a company by conferring the firm the legal ability to deny third parties the use of the protected invention. This requires the firm's ability to take legal action if required. The available empirical evidence suggests that the resource constraints faced by smaller companies limit their willingness and ability to engage in IP litigation. Nevertheless, there is some empirical evidence that smaller companies are able to sue larger third parties for infringement as the prospect of large damages enables them to mobilize sufficient financial resources to pursue legal action.
- Third, the managerial and organizational challenges of successful IP management weigh more heavily on smaller companies than larger ones. IP requires complex managerial processes which smaller companies may find difficult to put in place while they may lack the resources to purchase the necessary expertise from third parties. This problem is particularly taxing on small firms if they have to forego the wide range of possibilities for strategic filing behaviour offered by the patent system due their inability to establish and actively manage their IP strategy.
- Finally, firms that are part of multinational business groups appear to benefit in terms of their ability to take out formal IP. There are several factors at play including international knowledge sourcing, internal financial markets and markets for technology and qualified human resources. This may disadvantage smaller domestic firms, although it has also led to the emergence of a new type of small firm, the 'born global' SME.

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¹ See for example Granstrand (1999).

² Halcom (2010) reports that defendants include other large food companies such as Quaker Oats Co. and small companies and grocery stores that market own products in-store.

³ From a research perspective, more easily accessible data on large firms has certainly also contributed for the dominance of empirical research on large firms.

⁴ Schumpeter (1942) argued that large firms in imperfectly competitive markets would be rather able to innovate than small firms in competitive markets.

⁵ <http://www.ibm.com/ibm/licensing/patents/portfolio.shtml>

⁶ <http://petrobrasri.infoinvest.com.br>

⁷ See Songsakul et al. (2008) and <http://www.ic.gc.ca/eic/site/sbrp-pppe.nsf/eng/rd02412.html>

⁸ Size categories are defined as follows: micro firms 11-49 employees; SMEs 50-249 employees; large firms >250 employees. The size categories were adjusted using firms' turnover: firms with turnover EUR <2 million were classified as micro; with EUR 2 million and EUR <50 million are SMEs and EUR >50 million are large firms.

⁹ There are a total of 38,732 observations with the following distribution: 13,599 micro-sized firms; 19,656 SMEs; and 5,477 large companies.

¹⁰ The CIS is a stratified sample of registered enterprises in the UK with differing sample frames across the different survey waves. Hence, the shares of firms holding patents and trademarks may not be representative of the population of firms across sectors in the UK.

¹¹ The UK CIS only samples firms with >10 employees, which excludes micro-sized firms.

¹² Note that the sample consists of large companies (with median sales of approximately US\$130 million). However, the findings are likely to be even more pronounced for a comparison of SMEs and large companies.

¹³ A patent document is supposed to contain detailed technical information on the patented technology which is afforded to the patentee in return for granting the patentee the right to exclude third parties from using the patented invention. While this principle is often diluted in practice, it is still widely regarded as the central pillar of the patent system as evidenced in a passage taken from a court judgment handed by Hon. Judge Laddie at the UK Patents Court (Merck & Co. Inc vs Generics UK Ltd): "*A patent is a document written by the patentee for publication to the world at large and designed not only to set out clearly what the invention is but to describe the monopoly sought in unambiguous terms. It is supposed to be comprehensible to members of the relevant trade simply on reading. If our law has reached the stage where experiments and extensive expert evidence is admissible to aid in construing patents, then it suggests that something has gone wrong.*"

¹⁴ For example, Arora (1997) describes the early days of the organic chemical industry which provide an example of a situation in which firms resorted to both secrecy and patenting to protect innovations. Arora argues that certain chemical innovations were composed of tacit elements, notably the specific combination of different compounds, which were protected by secrecy, and codified knowledge (i.e. individual compounds that were protected by patents).

¹⁵ Alexey and Reitzig (2010), for example, argue that firms such as IBM attempt to mold the appropriability regime governing the software industry by actively promoting open science through patent pledges.

¹⁶ Gassmann and Bader (2006: 50) provide an example of the Swiss company Kern (Leica Geosystems) using a local bowling newsletter to issue defensive publications.

¹⁷ See also other initiatives, such as the Eco-Patent Commons in which 12 large multinational enterprises pledge some of their patents to allow third parties royalty-free access (Hall and Helmers, 2010).

¹⁸ Matthews et al. (2003) argue based on a survey of large UK firms that companies are very careful about simply abandoning patent rights and when in doubt prefer to maintain ownership. This requires a management system that ensures patents that might still be of (strategic) value are not light-mindedly abandoned, which requires strong coordination in particular among firms in business groups.

¹⁹ For a related case study on DuPont's patent donations see Bruner et al. (2005).

²⁰ This must not be confounded with so-called patent trolls. While there is no single definition for patent trolls, the term is commonly applied to entities that acquire existing IP rights to actively pursue potential infringement of these rights by third parties in order to generate licensing revenue which represents their sole source of income. The important characteristic of patent trolls is the fact that they neither invent nor produce themselves.

²¹ According to Eurostat (2003), the following criteria define members of business groups: (a) a legal unit directly owns at least 50% plus one of the voting rights in another legal unit. (b) A legal unit owns, by means of other subsidiaries, at least 50% plus one of the voting rights in another legal unit. (c) A legal unit fully consolidates the balance sheet of another legal unit and no other one consolidates the same legal unit.

²² For more information see <http://www.propintellectual.com.br>