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DO FIRMS PROFIT FROM PATENT LITIGATION? THE CONTINGENT ROLES OF DIVERSIFICATION AND INTANGIBLE ASSETS

Abstract

Prior research suggests that firms' ability to benefit from their technologies is determined by the strength of intellectual property (IP) laws and the inimitability of their technologies. We complement this explanation by suggesting that the generation of profits from technology is also driven by how effectively firms engage in *patent infringement litigation* (i.e., take legal action against their rivals) to create isolating mechanisms and protect their technologies. We contend that patent infringement litigation is characterized by *industry* and *geographic specificity* that affect (disproportionately*)* revenue generation and costs and, therefore, its net effect on firm profitability. By identifying contingencies that influence the economic returns from patent litigation, the analysis helps us understand why firms experience different profitability outcomes even when they operate in similar IP regimes and possess similar portfolios of technologies.

Keywords: *Patent infringement litigation; Performance; Profitability; Internationalization; Intangible assets; Product diversification; International diversification*

1. INTRODUCTION

A fundamental question in the innovation literature concerns the ability of firms to profit from their technologies (Lepak et al., 2007; Teece, 1986). Prior theoretical explanations suggest that firms generate economic rents and profits when factors such as complexity and causal ambiguity make their technologies *inimitable* (i.e., difficult and/or costly to imitate) (James et al., 2013; Kim, 2016). When technical knowledge is tacit, filing for a patent is less advantageous (Markman et al., 2004) and firms typically use other means to protect their technologies in such cases (Arundel, 2001). By contrast, technologies that rely on codified knowledge can be imitated and employed by competitors more easily (Sherry and Teece, 2004). In such instances, filing for patents and using intellectual property (IP) laws becomes the primary option for protecting technological assets.

Accordingly, the literature has suggested that, as long as firms' technologies are patented, they should be able to secure greater profits in environments with stronger IP protection. However, while legal institutions dictate who can legitimately use each technology (Jaffe and Lerner, 2011), they do not automatically prevent a firm's competitors from imitating or using its patented technologies (Rudy and Black, 2018). Thus, it is the firm itself that must pursue its legal rights by engaging in *patent infringement litigation* i.e., by seeking prosecution for those that infringe on its patents (James et al., 2013; Moser, 2013).[1] Although patent infringement litigation is a strategic action that any firm can take in order to protect and profit from its technologies, its effectiveness is not similar for all firms within a given IP environment (Liu et al., 2018). Surprisingly, despite

[1] *Patent infringement litigation*, which is the focus of our study, differs significantly from *patent litigation defence*, which results when the focal firm may have used, intentionally or not, the patents of other organizations. *Patent validity challenges* (both defence and litigation) are also beyond the scope of the study (even though the empirical analysis controls for the other three cases); these cases concern the issue of whether the patent is valid or not (Harhoff et al., 2016) and depending on the legal system of each country they might have to be heard in separate courts (rather than in those courts that hear infringement cases).

the financial, strategic, and technological implications of patent litigation (Harhoff et al., 2016; Jaffe and Lerner, 2011), we know very little about the factors that determine its effectiveness in helping firms to profit from their technologies (Chen et al., 2016; Mezzanotti, 2021; Schliessler, 2015).

To address this question, we examine how the decision of a focal firm to litigate organizations that potentially infringe on its patents affects its profitability. Patent infringement litigation in our framework is seen as a strategic action that creates *isolating mechanisms* – mechanisms that deter imitation and exclude the firm's rivals from using its patented technologies. Although patent litigation can potentially help firms generate revenues through the enforcement of their IP rights (Clarkson and Toh, 2010), it does not always increase firms' profitability (Chen et al., 2016; Mazzoleni and Nelson, 1998; Schliessler, 2015; Somaya, 2003). This is due to the considerable legal and organizational costs of litigation (Foss and Foss, 2005) and unpredictability in terms of its legal outcomes (Bessen and Meurer, 2008).

This duality prompts the need to identify the boundary conditions that determine the effectiveness of patent infringement litigation in increasing firm profitability. Drawing on work on patents and property rights, innovation and rent creation (Foss and Foss, 2005; Jaffe and Lerner, 2011; Teece, 1986), we contend that patent litigation is characterized by *industry* and *geographic specificity* that affect both revenue generation and costs. Motivated by this premise and the prominent role of diversification in affecting firm strategies and performance (Kafouros et al., 2018; Kim et al., 2015; Krammer, 2016; Lu and Beamish, 2004; Su and Tsang, 2015), we examine how the effectiveness of patent infringement litigation in increasing firm profitability is influenced by firms' portfolios of intangible assets as well as by their strategies to diversify across industries (*product diversification*) and across international markets (*foreign market diversification*).

To address our objectives, we match a sample of 3,627 firm-year observations of US firms in the IT industry with data on patent litigation cases associated with these firms during the 2004-2014 period. The empirical analysis shows that the profit-enhancing benefits of litigation are stronger for firms that are intensive in terms of intangible-assets. By contrast, firms with higher degrees of product and foreign market diversification profit less than their less-diversified counterparts. Our study makes three key contributions.

First, prior research on innovation and rent creation has focused on the strength of legal protection in a given jurisdiction, and has implicitly assumed a linear relationship between the strength of the legal framework and the returns from technologies or assets (Teece, 1986). Our study extends this explanation by advancing the premise that firms' profitability is driven by how effectively they use a given legal framework to litigate other firms, thereby creating isolating mechanisms and protecting their technologies. Such inter-firm differences in litigation may explain why organizations that possess similar technological endowments and operate in the same environment still differ in their ability to profit from their technologies (Nam et al., 2015). This explanation represents a significant departure from research that implicitly assumes that the quality or strength of IP regimes is the key driver of firm profitability (Adner and Kapoor, 2010; Kim, 2016).

Second, the resource-based view and studies about the role of intangible assets often consider 'inimitability' as an inherent property of technology that can assist in rent creation (Peteraf, 1993). However, they have largely ignored how firms can profit from assets that can be imitated by competitors, which is surprising given that most technologies are not inimitable by nature. Our study contributes to resource-based thinking by showing how firms can use patent litigation as a competitive weapon to create isolating mechanisms and profit from their technologies. It also shows that the profit-enhancing advantages of patent litigation are stronger

for intangible-asset-intensive firms complementing prior findings on the direct benefits of intangible assets (Delios and Beamish, 2001; Kafouros and Aliyev, 2016).

Finally, we contribute to the growing literature on litigation (Mazzoleni and Nelson, 1998; McDonagh and Helmers, 2013; Mejer and de la Potterie, 2012; Reitzig, 2004; Somaya, 2003) by providing new insights into how firm-specific contingencies make patent infringement litigation more (or less) profitable. Specifically, we develop theory on how the trade-offs between revenue-generating and cost-increasing effects of patent litigation are influenced by the firm's diversification strategies. By clarifying the role of industry and geographic specificities in patent litigation, our approach complements litigation studies that have started considering the role of institutional configuration, enforcement type, and market position (Rudy and Black, 2018); (Schliessler, 2015). In this way, we provide evidence on the *indirect* effects of diversification for firm profitability, suggesting that product and foreign market diversification may decrease the advantages of creating isolating mechanisms.

2. THEORETICAL DEVELOPMENT

2.1 The role of patent infringement litigation

The way in which patents are granted and the pursuit of patent infringement litigation by many organizations determine how much firms invest in R&D, the overall innovation ecosystem and the speed of business (Jaffe and Lerner, 2011). The extensive fragmentation of technologies across multiple entities (Hall and Ziedonis, 2001; Harhoff et al., 2016; Heller and Eisenberg, 1998) increases the probability of patent infringement by competitors, both intentionally or unintentionally (Bessen and Meurer, 2008). In such situations, litigation becomes an important tool that enables the patent holder (plaintiff) to request monetary compensation from its perceived

infringers, or secure an injunction to stop competitors from unauthorized use of its technologies (Lanjouw and Schankerman, 2001; Rudy and Black, 2018).

In the US, for instance, the plaintiff needs to file an action in Federal Courts that have almost exclusive jurisdiction over patent infringement, while appeals are heard by the Court of Appeals for Federal Circuit (CAFC). Federal Courts in the US can address both infringement cases as well as cases that challenge the validity of a patent (Mann and Underweiser, 2012; WIPO, 2018). Similarly, infringement and invalidity are decided simultaneously in the UK. By contrast, other countries (e.g. Germany) adopt the so-called bifurcated patent litigation system in which infringement and validity proceedings have to be heard separately by different courts (Cremers et al., 2016). Such variations matter because they affect the likelihood of infringers challenging the validity of the patent as well as the likelihood of settlement (Cremers et al., 2016).

Firms also differ significantly in how intensively they engage in patent infringement litigation (even after accounting for their size). Some firms litigate a large number of infringement cases for their size, whereas other firms decide to litigate less intensively. Despite such inter-firm variations, evidence shows that litigation has become more prominent. For instance, the overall number of cases filed in US district courts has more than doubled from 2009 to 2012 (Marco et al., 2017). Significant increases can also be observed in terms of the costs of litigation. As risks and complexity continue to mount, spending on litigation has nearly doubled in the period between 2005 and 2019, while the median spending for large firms in 2019 is four times higher compared to spending in 2015 (Morrison & Foerster, 2019).

2.2 How does patent infringement litigation affect firm profitability?

Despite a significant body of research on the implications of holding patent rights (Hsu and Ziedonis, 2013; Markman et al., 2004), a comprehensive understanding of how exactly patent

infringement litigation influences rent generation and profits in the firm remains elusive given the scope and complexity of factors involved in this process (Rudy and Black, 2018). Taking stock of these issues, we expect patent litigation to affect competitive advantages and profits either positively or negatively through a number of mechanisms.

On the one hand, several factors enhance a firm's effectiveness in preventing imitation by competitors and therefore its ability to profit from technology (Schmidt and Keil, 2013). First, patent infringement litigation helps the focal firm to "isolate" the use of its technologies by competitors and decrease potential market-stealing effects. The underlying logic for this premise rests upon the resource-based view that identifies isolating mechanisms as a necessary condition for a firm to achieve competitive advantages and generate rents from its assets (Lippman and Rumelt, 1982; Mahoney and Pandian, 1992). Without isolating mechanisms, the rents accruable to a technology would be competed away by competitors (Peteraf, 1993). Some technologies can be kept a secret or have inherent characteristics that make them difficult to imitate (e.g., when they rely on complex and tacit knowledge). However, patents involve codifiable and publicly accessible knowledge that is easier to identify, transfer and imitate. In such situations, patent infringement litigation becomes a major mechanism for isolating the firm's technology from rivals' imitation and use. Such isolation effects in turn allow the patentee to appropriate stronger economic rents and, thereby, profit from its technologies.

Second, patent infringement litigation helps the firm build a stronger reputation and competitive advantages by sending a strong signal to its rivals that the firm will seek to protect its assets in the event of infringement (Somaya, 2003). These reputational benefits not only protect the revenues that the firm's technologies generate but can also help the firm increase its visibility and marketing exposure (Galasso and Schankerman, 2015), further increasing revenue generation.

Third, patent litigation enhances firms' bargaining position in licensing negotiations. Firms can use litigation as a means of threatening to block rivals' access to important technologies. They can therefore force rival companies to accept arrangements and terms that are more favourable to them (Cohen et al., 2000) or directly increase the licencing fees that they charge. Such settlements can also enhance a firm's design freedom by opening up access to rivals' technology under favourable terms (Galasso and Schankerman, 2010) and thereby help the firm generate revenues in the future.

On the other hand, due to several other factors, patent infringement litigation can have the opposite effect and decrease firm profitability. First, firms that engage in patent litigation as plaintiffs incur significant direct and indirect costs (e.g., in contractual agreements, communication costs and legal fees)[2]. As a result, patent litigation can in certain cases outstrip the profits that firms can potentially make by virtue of owning patents (Bessen and Meurer, 2008). Second, patent litigation involves complicated law procedures (Somaya et al., 2007) and requires employees' attention towards specific areas of technology (Encaoua and Lefouili, 2005). It can therefore dilute managerial attention and capability (Somaya, 2003) and disrupt employees' participation in ongoing R&D projects, both of which decrease a firm's ability to generate new technologies and hence revenue (Somaya et al., 2007). Finally, litigation is inherently risky and uncertain. Indeed, the average chances of success are roughly fifty-fifty (Galasso, 2007). Hence, in many instances, litigation may actually increase costs without raising revenues, which can in turn translate into a significant reduction of profitability.

In conclusion, patent infringement litigation has the potential to increase a firm's revenues by blocking or putting off imitators, creating isolating mechanisms, and strengthening reputational

[2] Legal costs can be particularly high, with the median legal cost of patent litigation for a single-application single-patent suit being in the range of $1.6-2.8m (AIPLA, 2015).

spillovers and a firm's competitive advantage. However, the direct and indirect costs and the inherent risk involved may counterbalance these advantages and decrease a firm's profitability (Nam et al., 2015). Therefore, there is no universal relationship between patent infringement litigation and firm profitability, i.e., the relationship can change depending on certain conditions. To this end, we consider three firm-specific contingencies that affect this relationship and may therefore explain why litigation is a profitable strategy for some firms but not for others.

2.3 Hypothesis development

2.3.1 Firm's intangible assets

Intangible assets refer to intellectual property, such as patents, copyrights, licences, trademarks and brand names, that help firms gain competitive advantages, generate rents and increase their profitability (Kafouros and Aliyev, 2016). Firms differ in how intangible-asset-intensive they are (Blind et al., 2009) with some firms possessing a large portfolio of intangible assets (relative to their size) and others possessing a smaller portfolio.[3] We propose that the effectiveness of patent litigation in enhancing firm profitability will depend on the firm's portfolio of intangible assets, with patent litigation being more profitable for firms that are intangible-asset-intensive. Our reasoning rests on how the mechanisms discussed in the previous section influence revenue generation and firms' competitive advantages.

First, revenue is generated by a firm's portfolio of intangible assets (e.g. brand names, copyrights and patents) and the interplay between them, rather than by each patent alone (Makadok, 2001). As discussed earlier, litigation can protect such revenues by (partly) isolating a

[3] Intangible-asset-intensity refers to how much intangible assets a firm possesses relative to its size (i.e., the volume of intangible assets in the firm's portfolio over its size). As a construct, intangible-asset-intensity differs from product diversification. An intangible-asset-intensive firm might not be diversified in terms of products (e.g., Apple), while a firm that possesses a smaller portfolio of intangible assets might exploit its assets in multiple industries and product categories.

firm's patented technologies from rival use and imitation. We suggest that when a focal firm protects a core technology through litigation, it also protects other technologies/assets in its portfolio that are highly dependent on and have to be combined with that core technology. For instance, let us assume that an innovation relies on two technologies or assets (components A and B) that are both needed for its operation. If the focal firm succeeds to block its rivals from using component A, there are also potential benefits for component B as it will be less useful to its rivals (who will no longer be able to use component A).

Such interdependencies or complementarities have been validated by prior research (e.g., Alcácer and Zhao, 2012; Zhao, 2006) that shows that the value of some technologies diminishes for competitors when they do not have access to the core technology that is interconnected to this set of technologies or assets. In such instances, patent litigation can protect the revenues that are generated from the assets that are complementary to the focal patent (*in addition* to protecting the revenues that are directly generated from that patent). Given that these benefits are a direct function of the value and scale of the assets being isolated, we expect patent litigation to be more beneficial for asset-intensive firms than for less intensive ones in terms of intangible assets.

Second, the reputational advantages of litigation are stronger for intangible-asset-intensive firms. Patent litigation helps firms establish a reputation of being tough (Somaya, 2003), strengthens their position in licensing negotiations, and increases the visibility of their intangible assets. Hence, not only it makes a firm's rivals think twice before imitating its technologies, but it also serves as a form of advertising that can potentially increase the revenues that such assets generate (Galasso and Schankerman, 2015). While each litigation case is patent-specific, the above reputational benefits spill over to other intangible assets in the portfolio of the firm, including brand names and copyrights. Although such reputational spillovers help all firms increase revenues, their effects will be stronger for intangible-asset-intensive firms as they will apply to a

larger number of assets (Lanjouw and Schankerman, 2001). By contrast, when a firm's portfolio of intangible assets is small, fewer assets benefit from the above advantages and, therefore, the corresponding effects on revenue generation will be smaller.

In summary, we expect a firm's intangible asset intensity to improve the effectiveness of patent infringement litigation in increasing firm profitability both directly via protecting revenue streams and indirectly through reputational advantages. Hence:

H1: The role of patent infringement litigation in enhancing firm profitability is more effective for intangible asset intensive firms than for less intangible asset intensive firms.

2.3.2 Industry (product) diversification

Product diversification refers to the extent to which a firm has product operations across multiple industries (Palepu, 1985). Some firms focus on a single or few industries, while others redeploy their technologies across multiple sectors in an attempt to generate additional revenue. We contend that patent litigation is less profitable for firms with higher levels of product diversification than for firms with lower levels of product diversification. To explain these effects, we focus on the mechanisms that affect revenue generation and costs. Specifically, we argue that increases in costs will be greater for firms that are highly diversified, while revenue protection will be more difficult for these firms (compared to less diversified ones).

First, the link between litigation and profitability is weaker in the case of highly diversified firms as the isolating effects and other benefits stemming from each litigation case may only cover a small proportion of their product portfolio. Engaging in litigation may create isolating mechanisms, effectively nullify imitating competitors and combat the negative effects of "market stealing" on a firm's sales in those industries (Lieberman and Asaba, 2006). However, patent infringement litigation is in essence *industry-specific,* and therefore effective only in a particular,

limited context. Each litigation case is prepared for a specific industry context in which infringement occurred. The preparation of the firm for the litigation case as well as a court's ruling and decisions are based on that setting and its specificities that, together, directly influence the outcome of the lawsuit. As a result, the applicability of a patent infringement litigation case is less effective (or even invalid) outside of the particular industry context or product category for which the lawsuit was made. In addition, the focal firm faces different rivals in each industry. Hence, given that isolating mechanisms may not deter the different competitors that operate in other industries, they play a less significant role in protecting the stream of revenues of highly diversified firms.

Second, product diversification influences the relationship between patent litigation and firm profitability through its cost structure. To protect their entire portfolio of product lines in different industries, firms with higher levels of product diversification have to litigate multiple times and often against different competitors in each industry. This exacerbates the organizational, legal and transaction costs associated with the process of litigation (Somaya, 2003) as firms need to address (often in different courts) the specificity and the nature of each application in different industries. Even in cases in which the patent that is infringed is the same, the focal firm often needs to file a new lawsuit for applications in other industries (and potentially against different rivals) so that it can prove the alleged infringement. For these reasons, the costs and risks of litigation increase significantly for diversified firms.

In addition to higher legal costs, product diversification may increase the costs associated with the coordination and organization of the litigation process. Highly diversified firms face higher costs that may arise from the internal coordination of developing a lawsuit and from interacting with external law firms and organizations. Such coordination is more complex and therefore particularly costly for firms that diversify across different industrial contexts (Krammer,

2016; Lu and Beamish, 2004; Wiersema and Bowen, 2008). For these firms, mounting a litigation lawsuit is likely to compound organisational complexity, lead to significant disruption, and increase costs disproportionately to the overall competitive advantages and revenue gains associated with litigation.

To sum up, the costs of litigation are expected to be greater for highly diversified firms as litigation involves different contexts, requires greater coordination and leads to organizational disruption, all of which are expected to tilt the balance of litigation process on the costs side. As the costs and efforts for litigation increase with the degree of product diversification, the positive effects of patent litigation on firm profitability will diminish. Hence:

H2: The role of patent infringement litigation in enhancing firm profitability will be less effective for firms with a higher degree of product diversification than for firms with a lower degree of product diversification.

2.3.3 Foreign market (international) diversification

In addition to exploiting their technologies across different industries, firms can also employ them across different markets (Delios and Beamish, 1999; Kafouros et al., 2018; Lu and Beamish, 2004). Foreign market diversification refers to the extent to which a firm operates and generates revenues in foreign countries, reflecting therefore its degree of internationalization (Kafouros et al., 2018; Kim et al., 2015). In line with our reasoning for product diversification, we expect patent infringement litigation to be less effective in spurring the profitability of firms that are highly internationalized (and therefore a larger share of their revenues is generated abroad) than for less internationally oriented firms.

Foreign market diversification affects the relationship between patent infringement litigation and firm profitability by changing the jurisdiction responsible for enforcing IPR. Despite

the introduction of international agreements, patent litigation cases continue to be heard and judged on a county-by-country basis (Harhoff, 2009) and do not necessarily extend to jurisdictions beyond a national border. Firms that operate in foreign markets may protect home-country-specific revenues when they litigate in their home country. However, the advantages of creating isolating mechanisms through litigation are country-specific and do not transcend to foreign jurisdictions in which the firm operates (Caviggioli et al., 2013). Although agreements and court settlements between two firms may include several countries, the fact that each country is characterized by different rivals means that such settlements are either less effective or invalid abroad. Accordingly, we argue that the geographic specificity of patent litigation affects both revenue generation and costs, and therefore expect litigation to be more profitable for less internationally diversified firms for several reasons.

First, court decisions and legal settlements are enforceable in the country in which litigation is pursued. Due to the geographic (jurisdiction) specific nature of litigation, when highly internationalized firms pursue patent infringement litigation in their home country, they can potentially block imitators or reduce infringement in this market. However, home-country litigation is either irrelevant or becomes less effective when it comes to protecting foreign-generated revenues (as home-country court ruling might not be applicable in foreign countries). In contrast, the opposite pattern occurs for less internationally diversified firms (Caviggioli et al., 2013). As revenue generation in these firms is concentrated in the home country, they can better monitor the home market (Kafouros et al., 2008) and protect revenues through litigation. In such cases, patent infringement litigation is expected to have a more pronounced effect on their ability to create isolating mechanisms, deter imitation, sustain their competitive advantages and ultimately enhance revenues.

Second, foreign market diversification affects how cost-efficiently patent litigation can be

used. Highly internationalized firms need to litigate against the imitators of their patents in foreign countries if they want to protect revenues in these countries. As countries exhibit considerable differences in terms of culture, language, legal institutions, and the enforcement of IP rights (Kafouros et al., 2008; Krammer, 2018; Meyer et al., 2009), engaging in litigation abroad adds significant complexity and costs (Khoury and Peng, 2011). It increases the resources, time and costs associated with coordinating litigation across borders and with transacting with different legal authorities. By contrast, organizational complexity and the costs of protecting a given share of their portfolio of patents and associated revenues are lower when revenues are generated across fewer countries. Hence, we expect the effectiveness of patent litigation in enhancing profitability to be lower for highly internationalized firms.

Given these asymmetric effects of patent infringement litigation on the cost and revenue structure for internationally diversified firms, we introduce our last hypothesis:

H3: The role of patent infringement litigation in enhancing firm profitability is less effective for firms with a higher degree of foreign market diversification than for firms with a lower degree of foreign market diversification.

4. DATA AND METHODS

4.1 Empirical setting

To test these hypotheses, we employ a sample of firms operating in the information technology (IT) equipment industry in the U.S.A. This sector is highly innovative and intensive in proprietary patent litigation (Clarkson and Toh, 2010; Rudy and Black, 2018). The legal system in the U.S.A features strong IPR protection as well as strong enforcement of these rights, providing therefore incentives for firms to engage in patenting and litigation.

Court records of patent litigation cases can be accessed via specialised databases. We collected patent litigation data from the MaxVal Patent Litigation Databank (maxval.com). The database is based on patent litigation case records on PACER (Public Access to Court Electronic Records; pacer.gov), linking cases to relevant documentation. In selecting a sample, we considered two factors. First, matching firm-level data with litigation documentation involved manual work and required limiting the sample to the most relevant firms. Second, patent litigation activity cannot be easily pursued by very small firms given the significant financial costs. We collected data for firms with sales of over 5 million USD (the average over the observation period) to exclude firms that were very small and would typically lack the resources needed for patent litigation.

To avoid sampling bias, we included firms regardless of whether they were involved in litigation activity or not. We collected financial data from Thomson One Banker that includes the Worldscope and Compustat databases. The sample includes active and inactive firms that reported financial accounts during the period of 2004-2014 and operated under the SIC codes of "357(3571-3579): Computer and Office Equipment" and "36 (3610-3699): Electronic and other Electrical Equipment and Components, Except Computer Equipment" as their main activities. The final sample consisted of an unbalanced panel of 386 firms for the 2004 – 2014 period. However, a few firms were dissolved during the observation period, while others were established after 2004, resulting in an unbalanced panel dataset of 4,207 firm-year observations. Using one-year lags for independent variables meant that 3,165 observations remained in the final sample.

4.2 Dependent Variables

Our key dependent variable, firm profitability, is operationalized using each firm's Return on Sales (ROS, profit before tax to sales ratio), which is one of the most commonly-used measures for profitability (e.g. Chan et al., 2008; Shaner and Maznevski, 2011). Although our hypotheses focus

on firms' ROS, we also explored how patent litigation influences firm revenues and costs separately as additional analysis. Following Rudy and Black (2018), we estimated the market share of each firm using data collected from Thomson One Banker. Furthermore, we follow Hashai et al. (2018) and measure costs using each firm's General and Administrative Expenses divided by sales. These expenses (costs) consist of senior managers' compensation, costs of administrative employees, as well as legal, accounting, consulting, communication, and travel costs related to administrative activities.

4.3 Independent Variables

Patent Litigation

To construct a measure of a firm's proactive proprietary *patent infringement litigation* activity, we first identified the number (count) of patent infringement cases in which the firm was listed as a plaintiff in a patent infringement lawsuit for each year (Rudy and Black, 2018). To match firm names to patent litigation records, we followed three steps. Initially, we obtained all the litigation cases that contained the names of the firms in our sample. Second, we used fuzzy text matching to obtain matching scores. Third, all the cases with less than an exact matching score were revised manually to make sure that we correctly attribute each case to the right firms. In the initial matching process, we identified 3,570 cases where firms in our sample appeared in any role (plaintiff, defendant, counterclaimant, and counter-defendant). Then we filtered out patent infringement cases where firms in our sample appeared as a plaintiff. This resulted in 1,117 unique cases used for counting proprietary patent litigation activity. These cases belong to 149 unique firms (i.e., the rest of the firms in our sample of 386 firms did not have litigations during the observation period, but have remained in the sample to avoid selection bias). To measure *patent infringement litigation* as intensity (i.e., in a way that normalizes for firm size), we calculated the count of cases per

hundred employees in the firm. Hence, this independent variable reflects a firm's patent infringement litigation activity relative to its size.

Intangible Assets

To capture firms' *intangible assets*, we collected data on the book value of intangible assets reported in financial accounts. The book value of intangible assets[4] captures patents, copyrights, licenses that often result from R&D and advertising (Chang et al., 2013). It is one of the most widely used measures of intangible assets (examples of previous uses include Chang et al., 2013; Filatotchev and Piesse, 2009; Nachum, 2003; Wei and Liu, 2006; Zhang et al., 2014). We normalized the measure for firm size, using the ratio of intangible assets to the number of employees. For robustness-test purposes, we also used patents and R&D expenditure as alternative measures (discussed in the additional analysis section).

Product Diversification

A common limitation in measuring *product diversification* is the lack of data on the revenues in each product line. Although a measure that relies on the count of SIC codes can be used, it can be crude as it attaches equal weight to all industries. Previous studies developed imputed weighted diversification measures using the SIC codes reported in the Worldscope database, where industry codes are ranked in the order of their importance (Gedajlovic and Shapiro, 1998; Wan and Hoskisson, 2003). Gedajlovic and Shapiro (1998) found a correlation of 0.84 between the imputed weights method and the entropy measure of product diversification. Following these studies, we used data on the SIC codes from the Worldscope database to measure product diversification as

[4] In the US, GAAP recognition and capitalisation of intangible assets are regulated by ASC 340-20, 350 and 985-20. Intangible assets can be either acquired or internally developed. Development costs and advertising expenses when they are identifiable (e.g., as patents and trademarks) are expected to help the company generate revenue in future periods. Intangible assets with finite useful lives are amortised over their expected useful life. Subsequent expenses on intangible assets are capitalised only when it can be demonstrated that expenditure increases utility of the asset. For additional details, see the ASCs or KPMG (2015) and (RSM, 2014).

$D = \sum P_i \times d_{ij}$, where i and j stand for a firm's primary and secondary market segments respectively. d_{ij} takes one of the four values: 0 if the firm operates in only one four-digit industry, 1 if *j* is in the same three-digit industry as *i*, 2 if *j* is in the same two-digit industry as *i*, and 3 if *i* and *j* are in different two-digit industries. P_i is a weight imputed to each industry that is assumed to decline geometrically.[5] After obtaining industry-code-based imputed diversification, we regressed the measure against the intangible asset intensity of the firm and predicted the residual values. We used these residuals as a measure of firm diversification. By doing so, we measure the level of diversification for a given level of intangible asset intensity of the firm.

Foreign Market Diversification

Several studies have examined the role of foreign market diversification (Elia et al., 2020). Building on research that measures the level of internationalisation as a proportion of a firm's foreign activities, we operationalize *foreign market diversification* using the ratio of a firm's foreign sales to its total sales (FSTS) (Gomes and Ramaswamy, 1999; Ramaswamy et al., 1996). For the purposes of our study, this sales-based measure of internationalization is appropriate because it represents the share of the firm's international operations in its total operations. We lagged FSTS by one year in all our regressions.

4.4 Control Variables

We include several control variables as follows. Although our study focuses on patent infringement litigation, other types of patent litigation (Rudy and Black (2018) may influence firm performance including: *patent infringement defence*, patent *validity challenge litigation*, and

[5] For example, if a firm operates in three industries, the main industry takes the weight of 4/7, whereas the second and third industries take the weights of 2/7 and 1/7, respectively. For further details, see Gedajlovic and Shapiro (1998) and Wan and Hoskisson (2003).

validity challenge defence. Each of these activities is calculated in the same way as the main independent variable; that is, as counts per hundred employees of the firm.

Next, we control for a number of firm characteristics. Specifically, we control for firm size and resources by including one-year lagged measures of the number of *employees* and *tangible assets*. *Firm age* accounts for experience and reflects that new entrants and established firms are likely to experience different performance. Because the Thomson One Banker database did not report the year of inception, we calculate firm age as the number of years from the firm's first appearance in the database since 1986. Moreover, prior research suggests that *organizational slack* affects firm performance (e.g., Bradley et al., 2011; Bromiley, 1991; George, 2005). Given that patent litigation is a resource-intensive process, controlling for slack resources (also known as potential slack) is particularly important in the context of patent litigation. Following previous research (Rudy and Black, 2018), we control for slack using the firm's current assets (cash and other easily convertible assets) to total assets ratio (lagged by one year).

Apart from firm-level factors, it has been established that market competition influences firm conduct and performance (Peng et al., 2009). To account for industry concentration, we calculated the *Herfindahl index* for each industry at the four-digit level in each year. Finally, we included year-specific dummy variables to account for time specific shifts in firm performance.

To improve the normality of the variables and deal with extreme values, prior studies apply a logarithmic transformation to variables. However, given that firm profitability can take zero or negative values, a logarithmic transformation is not feasible. Therefore, we employ the Inverse Hyperbolic Sine (IHS) transformation (Burbidge et al., 1988). Formally, $IHS(x) = ln(x + \sqrt{(x^2) + 1})^2$. The benefit of IHS transformation is that it is based on logarithms and can be interpreted as the logarithmic transformation, but it can accommodate negative values as well

(Burbidge et al., 1988; Kafouros and Aliyev, 2016; Nyberg et al., 2010). Following common practice, we apply the IHS transformation to all independent variables as well.

5. RESULTS

5.1 Main results

Our analysis relies on panel data techniques. When the units of analysis (i.e., firms) have repeated observations over time, unobservable firm-specific effects may be correlated with the regressors, leading to inconsistent estimates (Wooldridge, 2002). When firm-specific effects are random, i.e., independent of the regressors, Random Effects (RE) techniques are preferred, whereas when firm-specific effects may be correlated with the regressors, Fixed Effects (FE) techniques should be used (Wooldridge, 2002). Therefore, in specifying the model, we started with a Hausman test of RE (as the efficient specification) and FE (as the consistent specification) models. The test returned the χ^2 value of 116.49 with p=0.000, rejecting the null hypothesis that the difference in coefficients is not systematic, suggesting that the FE model should be used.

Table 1 reports the descriptive statistics. The means and standard deviations are presented in nominal scales, while the correlations are presented in IHS transformation as used in the regressions. The correlation coefficients between the independent variables are low, and therefore there are no immediate concerns of potential multicollinearity. However, the inclusion of interactions may result in multicollinearity due to the repeated entries of the same variables. To test for multicollinearity, we calculated the linear variance inflation factors (VIFs)[6]. For the base model, the mean VIF was 1.97, ranging between 1.02 and 6.80 for each variable. For the full model, with potentially largest multicollinearity due to multiple simultaneous interactions, the

[6] To calculate the VIFs we used an OLS model, because VIFs are feasible only under OLS specification.

mean VIF was 2.72 with the range between 1.07 and 6.80. All the VIF values are well below the critical value of 10 (Myers, 1990). Table 2 reports the main results.

----- Tables 1 and 2 around here -----

Model 0 serves as the base model. The direct effect of patent infringement litigation intensity on firm profitability is negative and statistically significant. This finding suggests that, before taking account of the contingency effects developed in this paper, on average, the costs of patent litigation appear to exceed the realised benefits. Models 1 and 4 test the moderating effect of intangible asset intensity. The relevant interaction effect is positive and statistically significant at the 5% and 1% level. The positive moderating relationship supports Hypothesis 1, suggesting that asset-intensive firms benefit from litigation more than firms that are characterized by a lower intensity of intangible assets. To depict this moderation effect, we estimated and plotted the marginal effects of litigation for different levels of intangible assets per employee in Figure 1 (also showing 95% confidence intervals). The effect starts negative at the zero level of intangible asset intensity. Although the positive effect is statistically insignificant for lower levels of intangible asset intensity, this effect grows substantially and gains significance at moderate to higher intensity of intangible assets.

Models 2 and 4 test the interaction between *patent infringement litigation* and *product diversification*. The coefficient of the interaction term is negative and statistically significant at 0.1% level. This result supports Hypothesis 2, suggesting that product diversification negatively moderates the relationship between patent infringement litigation and performance. Figure 2 depicts the marginal effect of litigation for lower and higher levels of diversification. The effect of litigation on firm performance is weakly positive for focused firms, i.e. when the level of diversification equals zero. This effect vanishes at the moderate levels of diversification and becomes significantly negative for highly diversified firms. These results support Hypothesis 2.

Models 3 and 4 test the moderating role of foreign market diversification. The interaction effect between litigation and foreign market diversification is negative and statistically significant at the 5% and 1% level. This finding supports Hypothesis 3, confirming that the extent of the firm's foreign activity negatively moderates the relationship between litigation and firm performance.[7] Figure 3 depicts the marginal performance effects of litigation across different levels of firm internationalization, supporting the premise of the hypothesis.

----- Figures 1, 2, 3 around here -----

Furthermore, to better understand the economic significance of the hypothesized effects, we investigated the effect sizes by comparing the predicted values at the medians and the 99th percentiles of the main independent variables. We first calculated the predicted ROS values in IHS (as it was used in the regression) at the specified percentiles and the means of all other variables. We then took the inverse of the IHS transformation to return the ROS values to the original scale of percentage points.

Table 3a shows that at the median level of intangible asset intensity, the impact of patent infringement litigation moving from the median to the 99th percentile, on average, would move ROS from 0.51% down to the loss of 2.10%. Hence, the effect would be a loss of 2.61 percentage points of ROS, attributable to the move from the median to the 99th percentile of patent infringement litigation intensity. However, the same move for a firm operating at the 99th percentile of intangible asset intensity (the second line in Table 3a) would have its ROS change from 0.87% to 25.49%. Hence, the effect would be an increase in profit of 24.63 percentage points of ROS, attributable to the move from the median to the 99th percentile of patent infringement

[7] Furthermore, we have used each firm's "total assets" rather than "number of employees" to normalize the measures for firm size. The results are robust to this alternative scaling and remain similar to the main results reported in the paper. In addition, we re-ran the models after removing the "number of employees" as a control variable from the model. The results remained unchanged.

litigation. The bottom right cell displays the overall impact of the moderation as 27.24, which is the difference between the two cells above, or the two cells to its left.

----- Tables 3a, 3b, 3c around here -----

Table 3b shows the same calculation for product diversification. At the median level of product diversification, the predicted value of ROS is leading to losses of 2.72 percentage points attributable to the move from the median to the 99th percentile of patent infringement litigation intensity. The same move for a firm at the 99th percentile of product diversification leads to an increase in losses by 14.93 percentage points. Hence, the overall difference in losses attributable to the moderating effect is 12.21.

Table 3c shows the calculations for foreign market diversification. At the median level, there is an increase in losses of 2.70 percentage points attributable to the move from the median to the 99th percentile of patent infringement litigation intensity. The move at the 99th percentile has the impact of 8.52 percentage points. Hence, the overall impact is increase in losses by 5.82 percentage points in ROS.

Overall, the analysis of the effect sizes shows that patent infringement litigation is highly profitable for firms that are rich in intangible assets. However, high intensity of patent infringement litigation is less desirable for firms highly diversified across industries and internationally. Looking at the Tables 3a-3c collectively, we can see that if a firm is highly intensive in all three dimensions, patent infringement litigation activity would result in a net positive effect, due to the size of the positive effect of intangible asset intensity exceeding the combined size of the negative effects of product and international diversification.

Effects on market share and costs

To gain better understanding of the underlying effects, we have conducted a number of additional analyses. Specifically, we examined the effect of patent infringement litigation intensity on the firm's market share and costs. The reason for conducting this analysis is that litigation might have a positive effect on market share, but its net effect on profitability might be different due to the disproportionate impact on costs. To investigate whether this conjecture is valid, we used Market Share (MS) as the dependent variable in Model 5 and Costs in Model 6. To capture costs, we used Sales, General and Administrative expenses (SG&A), which is an important indicator of the firm's indirect expenses. Such expenses do not vary directly with the level of production but reflect the financial costs of the company's market strategies. Therefore, although SG&A might not necessarily represent all of the costs associated with patent litigation, it can serve as a proxy that reflects how litigation affects such costs.

Model 5 shows that the moderating effect of intangible asset intensity is positive and statistically significant, whereas its corresponding effect is statistically insignificant in Model 6. These findings conform to the logic that litigation is effective in gaining market share when firms are intangible-asset intensive, without necessarily increasing costs a lot. As a result, the net impact of intangible assets on the litigation-profitability relationship is positive. A different picture, however, appears for product and foreign market diversification as their moderating effects are statistically insignificant for Market Share in Model 5, but positive and significant for SG&A in Model 6. These findings corroborate the argument that product and foreign market diversification increase costs disproportionally, relative to the positive effects on the firm's competitive advantage.

Finally, Figure 4a depicts the overall effect of patent litigation in the form of frequency distribution of the estimated marginal profitability for the observations in our sample, i.e., we calculated the marginal effect of Patent Litigation Intensity for each observation in the sample at

their levels of intangible asset intensity, product diversification and foreign market diversification. We have done similar calculations for market share and costs (Figures 4b and 4c), which together provide a more comprehensive picture of the overall effects of patent litigation. Overall, 5% of the firms of our sample show configurations of intangible assets, product diversification, and foreign market diversification that would result in net positive Profitability from patent litigation. Figure 4b regarding Market Share shows that 30% of firms have a configuration that results in a positive net benefit in terms of gaining market share from patent litigation activity (this is primarily driven by intangible asset intensity). However, a similar analysis for costs shows that 75% of firms end up with increased costs when they pursue patent litigation (which are driven by higher levels of product and foreign market diversification). These Figures emphasize that the benefits of patent litigation are conditional on firm specific characteristics. While many firms benefit from patent litigation in terms of market share, the high cost of litigation means that only 5% of the firms of the sample experience a net positive outcome in terms of profitability.

----- Figures 4a, 4b, 4c around here -----

5.2 Robustness tests

Endogeneity

We conducted endogeneity tests for each of the main independent variables; namely, patent infringement litigation intensity, intangible asset intensity, product diversification, and foreign market diversification. Endogeneity tests require identifying instrumental variables and running Instrumental Variable (IV) estimations (in our case within the FE models; henceforth FEIV). Instruments must be *relevant* and *valid* (excludable), i.e. they must explain the independent variable without directly affecting the dependent variable, other than through the independent variable (Wooldridge, 2002). The *relevance* of the instruments can be tested with the F statistic of

the first stage equation. To test *validity*, we relied on the test of over-identifying restrictions. To run this test, the number of instruments must exceed the number of potentially-endogenous independent variables. Given that we ran these tests separately for each potentially-endogenous variable, we identified at least two instruments for each. Finally, the test of endogeneity is based on Hausman type statistic under the null hypothesis that the specified endogenous regressors can be treated as exogenous (Hayashi, 2000).

Given that we are using FE models, the within transformation removes firm-specific fixed effects. Hence, under the FE specification, a lag of a regressor and the value at time *t* do not have firm fixed effects as a common element. Therefore, we use lagged regressors as instruments. Moreover, although firm-specific variables are determined at the firm level, they are also influenced by industry-specific norms and technological characteristics. Therefore, for each potentially endogenous regressor, we also use the lagged industry-year average of the corresponding regressor. We employ this logic consistently for each regressor. In all cases, the under-identification tests showed that the instruments were sufficiently relevant. The instrument validity tests showed that the instruments were valid, suggesting that we could undertake the endogeneity tests. Finally, the endogeneity tests showed that the coefficient estimates in FEIV models did not differ from the coefficients in the FE models systematically, hence the regressors could be treated as exogenous (Hayashi, 2000; Wooldridge, 2002). Overall, this additional analysis shows that endogeneity does not pose a significant threat to our estimations.

Selection bias

We further considered the possibility that as firms make decisions on patent infringement litigation, they are affected by a *selection* process. If the selection process is correlated with unobservable factors, e.g. the firm's reputation of "toughness" in the market, the coefficient values

could be biased. Although, the time invariant proportion of such effects would largely be removed in the FE within transformation, we undertook a test of potential selection effects to check if there are significant time-varying unobserved factors influencing the results. This problem is akin to selection problems that could be addressed with a Heckman model. The difference from a traditional Heckman setting is that we can observe firm profits even if there is no litigation, while the dependent variable in the traditional Heckman model would not be observed in the observations that are not selected. However, the problem in our analysis is similar to the Heckman selection problem in the sense that if there is a selection bias caused by unobserved effects, it would be hidden in the error term. With this in mind, we estimated a Heckman type model in FE specification. In a Probit model, we investigated whether filing a new patent litigation case (dummy=1 if a firm files a new patent infringement case) is predicted by the cumulative sum of patent infringement litigation filings up to the year t-1. This effectively allows us to check whether litigation activity at time *t* is predicted by prior litigation activity. We further included lagged Working Capital as a proxy for the availability of current assets (cash) because litigation is a cash-demanding activity; and year-specific dummy variables to capture the time trend in the litigation activity. The Heckman two stage model is needed if $\rho \neq 0$ (where ρ is the correlation between the error terms from the first and second stages of the Heckman model). If $\rho=0$, then there is no correlation between the error terms in the two stages, i.e., the Heckman model is not needed. In other words, it would mean that there is no statistically significant bias in the model. The Wald test of independent equations failed to reject the null hypothesis that $\rho = 0$ (p-value = 0.439), concluding that the Heckman model was not needed.

Overall, the test shows that there is no statistically significant selection bias caused by unobserved effects. One explanation is that unobserved effects are mostly time-invariant, and the

FE specification removes such effects. In other words, they no longer constitute a part of the error term and therefore they do not cause bias.

Alternative explanations: Domestic performance

One limitation of the analysis is that it relies on domestic patent litigation data, while firm performance reflects both domestic and foreign operations. From a theoretical point of view, this does not pose a significant issue as the US is likely to be the largest market for the firms in our sample. Nevertheless, we undertook a robustness test, to check if the US-based litigation activity would provide similar outcomes for US-specific firm performance. Using foreign operating income (OpInc) and foreign sales indicators reported in the income statement, we calculated an alternative dependent variable representing "domestic operations" as (Total OpInc – Foreign OpInc)/(Total Sales – Foreign Sales). In other words, by removing foreign operating income and foreign sales, we estimated the domestic return on domestic sales. Theoretically, domestic operations should not be influenced significantly by litigation activity in foreign jurisdictions. We re-estimated the models with this alternative dependent variable. The results fully supported the main findings of our study.

Alternate measures of firm performance: stock market value

We further investigated the robustness of the results to an alternative measure of firm performance. Although we theorised about the impact of patent infringement litigation on firm profitability, we investigated whether the effects hold for the stock market performance of the traded firms in our sample. Accordingly, we have employed an event study analysis (Fama et al., 1969) for the traded companies in our dataset. Event study methods are widely used in the finance literature to investigate the consequences of significant events (e.g., policy announcements, natural disasters)

as well as firm-specific events such as earning announcements, M&As, and litigation. This analysis involves four steps: (i) measuring stock returns during the event period, (ii) estimating the expected return that would have occurred without the event, (iii) estimating the abnormal return, and (iv) attributing the abnormal returns to the factors of interest (Bhagat and Romano, 2002; Fama et al., 1969).

We collected monthly stock data for US firms with SIC industry codes of 360-369 and 357 from the ORBIS database and matched the stock price data with our dataset using ticker symbols. ORBIS had stock price data for 252 (out of 386) firms in our sample. The earliest ORBIS data was available for January 2005. We matched monthly data with litigation cases (the events) based on the litigation case filing month. Yearly measured variables were matched based on the firm-year preceding the month of filing the litigation case. We measured 'abnormal returns' following the literature and using the difference between stock returns and stock-specific *expected returns*. Calculating expected returns presumes the estimation of a regression function that can predict "normal" returns, deviations from which are the *abnormal* returns.

To calculate expected returns we followed the four-factor Fama-French model (Fama and French, 1992). Although many studies use only market β, Fama and French (1992) show that using four additional factors of size (market capitalization), book-to-market equity, leverage, and earnings-price ratio helps capture heterogeneity more precisely and improve the estimation of the expected returns. Formally:

$$R_{it} = \alpha_i + \beta_i R_{mt} + \sum \gamma_{ij} F_{ijt} + e_{it} \quad (1)$$

$$E(R_{it}) = \hat{\alpha}_i + \hat{\beta}_i R_{mt} + \sum \hat{\gamma}_{ij} F_{ijt} \quad (2)$$

Where R_{it} is the firm-specific return, R_{mt} is market rate of return, and F_{ijt} are the j factors mentioned above. The firm-specific returns were calculated as a monthly return, i.e. the difference

between the closing and the opening stock prices. To measure the market rate of return we used NASDAQ composite stock market index as it is an index weighted towards information technology companies. The F_{ijt} factors were calculated following (Fama and French, 1992): *size* as the log of market capitalization; *book-to-market equity* as the log of book value of shareholder equity to market capitalization ratio; *leverage* as the log of total assets to book value of shareholder equity ratio; and the earnings-price ratio was captured with two variables: the log of earnings-per-share to stock price ratio when the earnings are positive, and a dummy variable taking the value of one when the earnings are negative, because "when current earnings are negative, they are not a proxy for the earnings forecasts embedded in the stock price, and E/P is not a proxy for expected returns" (Fama and French, 1992, p.444).

Given the coefficients β_i and γ_{ij} are stock-specific, equation (1) must be estimated separately for each firm. Ideally, we would use a certain daily stock price-based estimation window preceding the event. However, given we are using monthly stock price data, to ensure sufficiently large number of observations for each stock, we relied on the entire period as an estimation window. However, we excluded the months where the focal company was involved in any type of litigation activity (i.e., all months when the cases lasted, because new developments on the case may come in as the case progresses and influence stock returns). Expected return $E(R_{it})$ for an event in month t is then calculated using the estimated parameters, as shown in equation (2). Abnormal returns AR_{it} were calculated as the difference between stock returns R_{it} and the estimated expected returns $E(R_{it})$:

$$AR_{it} = R_{it} - E(R_{it}) \quad (3)$$

The abnormal returns are standardized using the standard deviation of regression residuals, which were used in a second stage regression analysis to analyse the heterogeneous effects of patent litigation cases across firms (Bhagat and Romano, 2002; Song and Walkling, 2000). These results

are reported in Model 7 (Table 2) and show a pattern similar to the main results of our analysis. These findings therefore indicate that the theoretical conjectures in the paper are supported even when using a very different proxy for firm performance, namely abnormal stock returns.

Alternate measures for intangible assets: Patents and R&D expenditures

We have further tested the hypotheses after using each firm's patent stock and R&D stock instead of intangible assets. Using the databases provided by Arora et al. (2017) and PatentsView, we collected data on 406,368 patents that belong to the firms of our sample (the Appendix provides a detailed description of the data collection and matching procedure). In this sample, 258,856 of these were patents granted during the period of our study 2004-2014, while the remaining 147,512 patents were granted between 1980-2003. We needed the latter for constructing a patent stock variable using the perpetual inventory method (described below).

Collecting information on patent stocks also allowed us to recalculate an alternative measure of patent litigation. To estimate firm propensity to litigate (or have its patents infringed), we ran a model on the *expected* litigation/infringement, given a firm's patent stock and size. To calculate the patent stock for each firm, we used the perpetual inventory method (Arora et al., 2017; Belenzon and Berkovitz, 2010), as $S_t = P_t + (1 - \delta)S_{t-1}$, where *S* represents patent stock in year *t*, *P* represents the number of patents granted to the firm in year *t*, and δ is a 15% depreciation rate. Using the patent stock (as a proxy for exposure to patent infringement) and the number of employees (as a proxy for firm size), we regressed Patent Litigation Counts against the log of Patent Stock and the log of employees (we used a negative binomial model due to the count-based dependent variable).

Using this model, we predicted the *expected* Patent Litigation propensity for a given level of patent stock and size in each year ($PL_{expected}$). We used this as a proxy for the likelihood of

infringements. Using this proxy, we calculated Patent Litigation Intensity (PLI) as PLI = PL_{actual} / $PL_{expected}$. Hence, PLI reflects intensity in terms of how many times the actual patent litigation is higher than the expected one. Using the new PLI variable, we re-tested the hypotheses. Model 8 in Table 2 reports the results of this test, which are similar to the main findings.

Finally, we conducted the above process again using the R&D stock of each firm, rather than its patent stock (Mavroudi et al., 2020). Accordingly, we collected data on firms' R&D spending from Thomson One Banker. Once again, we used the perpetual inventory method to calculate R&D stock per employee (data for 18 firms were missing) and re-test the hypotheses. Model 9 in Table 2 reports the new results, which once again remain robust.

6. DISCUSSION AND CONCLUSIONS

6.1 Theoretical Contributions

Despite the growing strategic, technological and economic importance of patent infringement litigation (Cremers et al., 2016; Lepak et al., 2007; Mezzanotti, 2021; Rudy and Black, 2018), knowledge of how it affects firm profitability remains incomplete (Chen et al., 2016). Various complexities make it difficult for theory to predict whether the revenue-enhancing effects of patent infringement litigation outweigh the associated costs. As a universal relationship between patent infringement litigation and firm profitability does not exist, this research focuses on identifying certain boundary conditions that improve or impede the effectiveness of patent litigation in increasing firm profitability, and clarifies the mechanisms through which such effects occur. Accordingly, it makes three contributions.

First, our study shifts the focus of the innovation literature from variations in the strength of IP regimes to how effectively firms use a given IP regime to protect and profit from their technologies. Prior theoretical explanations about the mechanisms that enable firms to profit from

technology focus on the strength of legal institutions in a jurisdiction (Foss and Foss, 2005; Teece, 1986). We advance these conceptualizations by developing the view that the generation of rents and profits is driven by how effective firms are in engaging in patent infringement litigation. Our view puts the firm at the centre of such explanations and underscores the importance of using IP laws to create strong isolating mechanisms that increase the returns from technology. Therefore, such inter-firm differences in litigation help us explain why firms that operate in the same IP regime and possess a similar level of technological endowment may experience different profitability outcomes (Nam et al., 2015).

Second, we contribute to resource-based thinking and in particular to research on the importance of intangible assets. Specifically, research within the RBV tradition often views inimitability as an inherent property of technology and suggests that inimitable assets can generate strong returns (Peteraf, 1993). However, it has placed little emphasis on how economic rents and profits can be generated from assets that can be imitated by competitors. Our study contributes to resource-based thinking by showing how the isolating mechanisms created through patent litigation can help in this respect. Understanding how firms can increase the inimitability of their technologies is particularly important given that most technologies are not inimitable by nature. Furthermore, our analysis reveals that intangible-asset-intensive firms gain more from patent litigation because asset interconnectedness and reputational benefits increase the advantages of creating isolating mechanisms. Hence, besides helping firms to outperform rivals (Delios and Beamish, 2001), our study shows that intangible assets contribute to firm performance indirectly by helping firms leverage returns from litigation. This conforms to the reasoning regarding the strategic use of litigation for building up reputational advantages (Somaya, 2003) and as a strategy that not only protects but also promotes the visibility of firms' products, technologies and assets (Galasso and Schankerman, 2015; Lanjouw and Schankerman, 2001).

Third, prior research has emphasized the importance of understanding how patent policy and patent practice, including litigation, affect economic outcomes (Jaffe and Lerner, 2011; Mezzanotti, 2021). We contribute to the growing literature on patent litigation (McDonagh and Helmers, 2013; Rudy and Black, 2018; Somaya, 2003) by providing an explanation for conflicting findings regarding its effect on firm performance (Chen et al., 2016). Although patent infringement litigation can protect revenues, it involves significant legal, organizational and transaction costs that can decrease firm profitability. We theorize that the positive and negative effects of patent litigation are contingent on the characteristics of the focal firm pursuing litigation. To understand this trade-off, we conceptualize litigation as a mechanism that reduces rent dissipation from IP and link it to firms' diversification strategies.

Developing the premise that patent litigation is characterized by *industry* and *geographic specificity*, we contend that product and foreign market diversification strategies affect negatively the relationship between patent infringement litigation and firm profitability by increasing the difficulties, complexities and costs encountered across multiple industries and countries. Our analysis therefore also contributes to the literatures on product and foreign market diversification by shifting the discussion from the direct implications of diversification strategies (Palich et al., 2000) to their indirect effects in determining rent and profit generation from technology, suggesting that higher diversification levels reduce the advantages of creating isolating mechanisms through litigation.

6.2 Practical Implications

Our analysis supports the view that firms can use patent infringement litigation as a competitive weapon to create isolating mechanisms and safeguard the economic rents that their technologies can potentially generate. This however does not necessarily mean that all firms succeed in doing

so. While patent litigation helps firms increase revenues, the associated costs are very high and therefore only 5% of the firms of our sample could manage to profit from it. The significant variations in how effectively firms pursue patent infringement litigation highlight the managerial importance of considering both the industry and geographic specificity of patent litigation. Context specificities determine revenue generation and costs and therefore the net profitability outcomes of patent litigation. Given that a significant challenge for firms is to understand where the actual balance between the costs and revenue-enhancing benefits of litigation lies, managers should be aware that litigation is likely to lead to less profitable outcomes when a firm's product and foreign market diversification levels are high. This finding does not imply that firms should not engage in litigation when they are diversified, but it does suggest that protecting technology through patent infringement litigation might be less profitable in such cases.

Furthermore, geographic specificities also influence the effects on patent infringement litigation on firm profitability. Entering foreign markets requires firms to understand host-country IP laws, court systems and provisions. This increases various types of costs and, according to our findings, decreases the potential gains of litigation as firms that diversify in multiple countries are less likely to uphold their patented technologies in all the markets they enter. The findings do not imply that firms should not diversify (as there are other reasons and benefits for diversifying), but they do suggest that alternative isolating mechanisms and strategies (e.g., fragmenting the development of technologies; Zhao, 2006) should be used to protect their technologies. Nevertheless, despite these negative moderating effects, it is worth noting from the point of view of strategic management that many firms that are intangible-asset intensive are more likely to benefit from patent litigation even when they are diversified.

6.3 Limitations and Future Research

While our study provides insights into how certain contingencies change the effectiveness of patent litigation in improving profitability, a number of limitations and promising research avenues remain. First, we focused on the contingencies associated with each firm's intangible assets and diversification strategies. Future efforts can focus on different contingencies either about the focal firm (e.g., its competitive position and IP strategy) or consider the characteristics of its rivals. The latter is particularly important as the effects of litigation might depend on which competitors are imitating the technologies of the focal firm. Different firm competitors may possess different experience, resources and patent portfolios and such characteristics may determine the effects of patent litigation on firm performance.

Second, we focused on litigation in the U.S.A but we did not capture litigation in foreign markets by US firms against foreign infringers. Due to the dominance of the US in the IT industry, it is highly likely that the firms of our sample litigate in the US in the first instance, and if they litigate abroad it is likely that they also do in the US. Although we conducted additional analysis to evaluate the effects of litigation on the domestic performance of firms, it would be valuable for future research to trace all the foreign subsidiaries of each focal firm, identify valid litigation data for all the countries in which they have foreign operations, and either examine such effects on firm performance or consider the strategic reasons behind choosing to litigate at home and/or abroad.

Third, firms often engage in litigation both as plaintiffs and defendants. Several examples from practice show that firms sometimes countersue each other on multiple counts of infringement. In addition, firms engage in validity challenges. While we have empirically controlled for these alternate options, future research might focus on explaining in which instances and how firms engage in litigation defence and validity challenges as opposed to infringement litigation. Such inquiries may yield novel theoretical and empirical insights for the innovation literature.

Finally, as patent thickets are more common in some industries than others (Harhoff et al., 2016), our findings might be conservatory compared to other industry settings that may rely more heavily on patent litigation. Similarly (and as mentioned earlier), given that there are significant cross-country variations in technology, legal systems and in how courts interpret and enforce the law (Cremers et al., 2016; Kenney et al., 2009; Mazzoleni and Nelson, 1998; McDonagh and Helmers, 2013), we would expect patent litigation outcomes to vary when firms litigate abroad. A fruitful avenue for future research would be to examine cross-industry and cross-country contexts and identify the influences that different institutional idiosyncrasies, patent systems (Jaffe and Lerner, 2011) and industry-specific characteristics introduce when considering the determinants and consequences of patent litigation across different contexts.

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TABLES AND FIGURES

Table 1 Descriptive statistics

	Variable	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12
1	Return on Sales (%)	-6.36	68.69												
2	Patent infringement litigation	0.09	2.22	-0.01											
3	Intangible asset intensity	0.16	5.43	0.03	0.00										
4	Product diversification	0.00	0.34	0.05	0.00	-0.02									
5	Foreign market diversification (FSTS)	0.41	0.33	0.06	-0.05	0.02	-0.17								
6	Patent infringement defence	0.12	0.77	-0.06	0.24	0.00	0.06	-0.03							
7	Validity challenge litigation	0.00	0.05	0.00	0.02	0.01	-0.01	0.04	0.16						
8	Validity challenge defence	0.00	0.04	-0.03	0.10	0.02	-0.06	-0.01	0.06	0.00					
9	Employees	9,814	35,863	0.27	-0.12	-0.04	0.05	0.39	-0.19	-0.03	-0.03				
10	Tangible assets	1,165	6,365	0.27	-0.06	0.08	0.06	0.44	-0.16	-0.03	-0.02	0.90			
11	Firm age	14.68	5.97	0.14	-0.01	0.00	0.10	0.11	-0.01	-0.08	0.01	0.32	0.30		
12	Slack	0.65	0.19	0.04	0.07	-0.28	-0.02	-0.08	0.16	0.05	-0.01	-0.37	-0.48	-0.12	
13	Herfindahl Index	0.06	0.05	-0.01	0.00	0.00	0.10	-0.03	-0.01	-0.01	0.01	0.07	0.02	0.10	0.09

Notes: Number of observations: 3,165.

Table 2. Results of the Fixed Effects regression analysis

	M0	**M1**	**M2**	**M3**	**M4**	**M5**	**M6**	**M7**	**M8**	**M9**
Dependent variable:	ROS	ROS	ROS	ROS	ROS	Market Sh.	SG&A	CAR	ROS	ROS
Patent infringement litigation (PIL)	-2.495**	-3.384**	-2.882***	-1.473+	-2.719***	-0.001	-0.008	-1.226+	0.092	-2.425**
	(0.726)	(1.046)	(0.493)	(0.825)	(0.719)	(0.001)	(0.031)	(0.609)	(0.542)	(0.735)
Intangible asset intensity (IA)	0.550	0.511	0.543	0.547	0.504	0.001	-0.006	-0.803	0.929	0.267
	(0.489)	(0.446)	(0.482)	(0.487)	(0.440)	(0.001)	(0.029)	(3.219)	(0.898)	(0.527)
Product diversification (PD)	-0.678	-0.319	-0.711	-0.705	-0.395	0.011+	0.167	49.669*	-0.898	-0.958
	(2.618)	(2.720)	(2.665)	(2.603)	(2.736)	(0.006)	(0.278)	(23.106)	(1.969)	(1.995)
Foreign market diversification (FMD)	0.035	0.049	0.037	0.086	0.097	0.001+	-0.024	1.984	0.111	0.082
	(0.353)	(0.348)	(0.356)	(0.360)	(0.358)	(0.001)	(0.015)	(1.380)	(0.411)	(0.360)
H1: PIL x IA		**14.220***			**13.374****	**0.013*****	**-0.450**	**4.777***	**0.433****	**0.710*****
		(5.438)			(4.265)	(0.004)	(0.401)	(1.728)	(0.142)	(0.193)
H2: PIL x PD			**-5.071*****		**-4.444*****	**-0.004**	**0.188*****	**-6.207****	**-0.152***	**-5.373*****
			(0.880)		(0.814)	(0.005)	(0.053)	(1.803)	(0.068)	(0.905)
H3: PIL x FMD				**-4.269***	**-3.974****	**-0.002**	**0.271****	**-4.055****	**-0.097***	**-3.390***
				(1.780)	(1.406)	(0.002)	(0.096)	(1.303)	(0.046)	(1.559)
Patent infringement defence	-0.134	-0.113	-0.069	-0.170	-0.092	0.001+	0.012	-1.554***	-0.027	-0.161
	(0.182)	(0.178)	(0.192)	(0.174)	(0.182)	(0.000)	(0.013)	(0.214)	(0.022)	(0.194)
Validity challenge litigation	-0.326	-0.326	-0.497	-0.344	-0.492	-0.001	-0.071	-2.729***	0.174	-0.524
	(1.103)	(1.072)	(1.172)	(1.136)	(1.165)	(0.001)	(0.051)	(0.369)	(0.181)	(1.234)
Validity challenge defence	-1.586	-1.726	-1.723	-1.485	-1.743	-0.003	0.077*	-4.100***	-0.136+	-1.667
	(1.014)	(1.156)	(1.072)	(1.008)	(1.183)	(0.002)	(0.035)	(0.594)	(0.074)	(1.070)
Employees	-0.416**	-0.406**	-0.413**	-0.421**	-0.408**	-0.000	-0.013	1.865	-0.365*	-0.430**
	(0.131)	(0.127)	(0.128)	(0.131)	(0.126)	(0.000)	(0.017)	(1.522)	(0.159)	(0.145)
Tangible assets	0.075	0.078	0.081	0.079	0.087	0.002**	-0.006	0.195	0.140	0.091
	(0.107)	(0.105)	(0.108)	(0.106)	(0.106)	(0.001)	(0.019)	(1.347)	(0.123)	(0.108)
Firm age	-0.058	-0.065	-0.057	-0.033	-0.041	-0.007+	0.037	-1.892	1.090+	-0.119
	(0.465)	(0.466)	(0.464)	(0.477)	(0.476)	(0.004)	(0.026)	(1.380)	(0.561)	(0.480)
Slack	4.205***	4.206***	4.219***	4.231***	4.242***	-0.003	-0.017	-25.473**	4.119***	3.974***
	(0.538)	(0.546)	(0.543)	(0.546)	(0.557)	(0.003)	(0.088)	(8.374)	(0.539)	(0.541)
Herfindahl Index	15.992	15.512	17.429	16.119	16.919	0.091*	-0.596	13.497	12.243	17.547+
	(10.673)	(10.749)	(10.407)	(10.630)	(10.451)	(0.042)	(0.850)	(16.812)	(9.704)	(10.205)
Constant	-0.095	-0.131	-0.241	-0.204	-0.358	0.016	0.398**	9.430	-4.661*	0.127
	(1.653)	(1.672)	(1.679)	(1.688)	(1.726)	(0.012)	(0.123)	(7.102)	(2.025)	(1.755)
R-squared	0.083	0.084	0.085	0.084	0.087	0.063	0.017	0.017	0.081	0.085

Notes: Fixed Effects models; Year specific dummy variables are included; Figures in parentheses are cluster robust standard errors. Number of observations: in M1-M6: 3,165; M7:1033; M8: 2857; M9: 3020. *** p<0.001, ** p<0.01, * p<0.05, + p<0.1

Table 3a. Effect size of *intangible asset intensity*

ROS (%) at:		Patent infringement litigation		ΔROS
		Median	99th pc	
Intangible asset intensity	Median	0.51	-2.10	-2.61
	99th pc	0.87	25.49	24.63
	ΔROS	0.35	27.59	**27.24**

Table 3b. Effect size of *product diversification*

ROS (%) at:		Patent infringement litigation		ΔROS
		Median	99th pc	
Product diversification	Median	0.50	-2.21	-2.72
	99th pc	0.15	-14.77	-14.93
	ΔROS	-0.35	-12.56	**-12.21**

Table 3c. Effect size of *foreign market diversification*

ROS (%) at:		Patent infringement litigation		ΔROS
		Median	99th pc	
Foreign market diversification	Median	0.55	-2.15	-2.70
	99th pc	0.60	-7.93	-8.52
	ΔROS	0.05	-5.77	**-5.82**

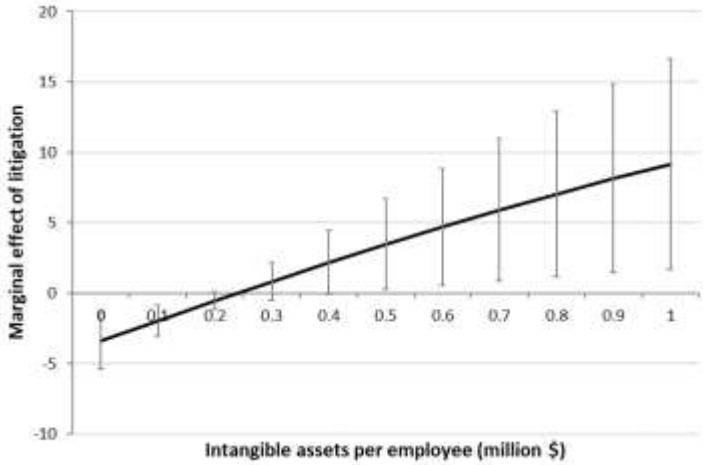

Figure 1. Marginal effects of litigation at different levels of intangible asset intensity

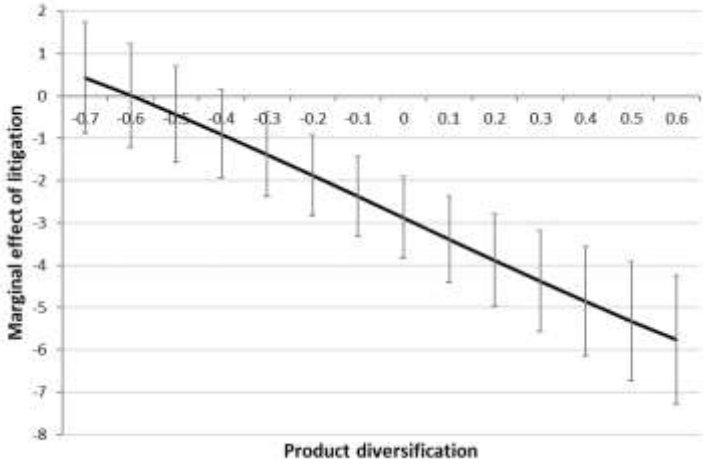

Figure 2. Marginal effects of litigation at different levels of product diversification

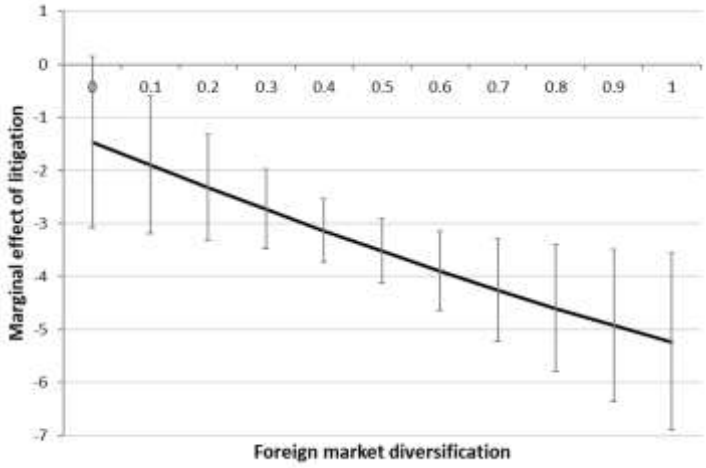

Figure 3. Marginal effects of litigation at different levels of foreign market diversification

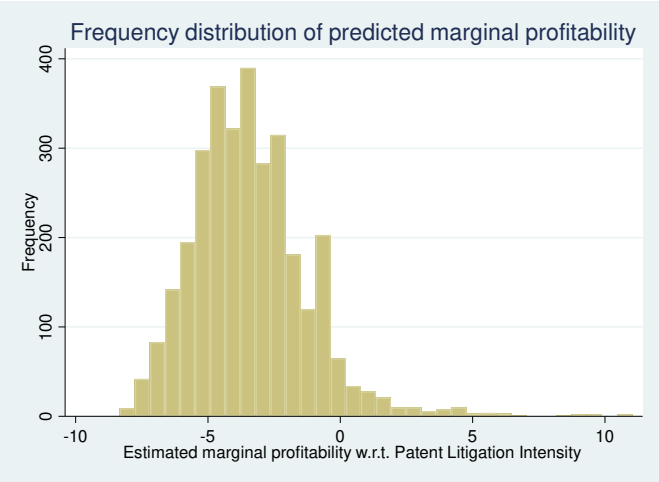

Figure 4a: Frequency distribution of predicted marginal profitability

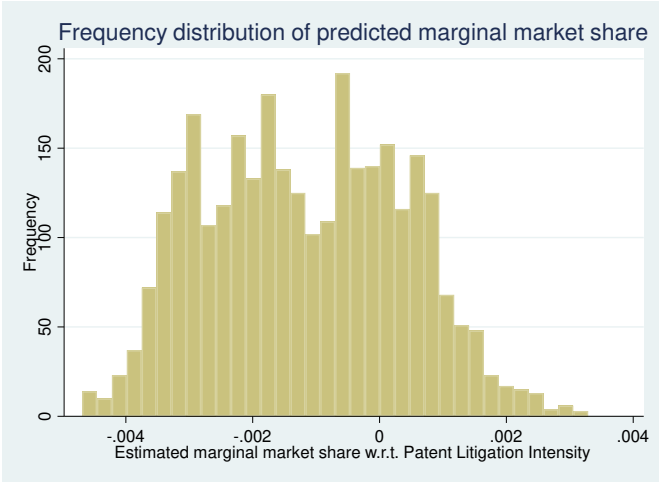

Figure 4b: Frequency distribution of predicted marginal market share

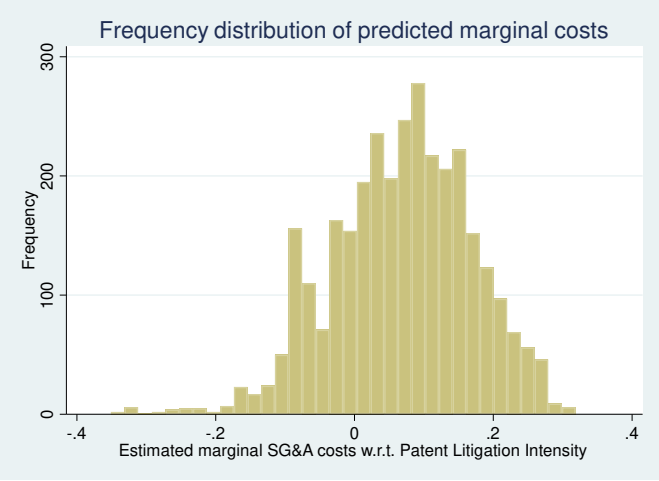

Figure 4c: Frequency distribution of predicted costs

APPENDIX

Patent data matching procedure

We used two sources in order to collect patent data. The first source was the database provided by Arora et al. (2017). The authors constructed historical firm-patent links for publicly traded firms. They sampled US publicly traded firms and linked these to assignee names in USPTO, which then enabled them to attribute patents to each firm. Their patent search covers all USPTO granted patents between 1980-2015, including the period of our study (2004-2014).

Our dataset consists of 383 traded and non-traded firms. Matching these with the data in Arora et al. (2017) resulted in 252 matches, covering all the years we needed. This matching resulted in a dataset of 285,853 patents: 186,089 were patents granted between 2004-2014, and 99,764 during 1980-2003. Due to the perpetual stock method used for calculating the patent stock (described below), going back several years increases the precision of the patent stock calculation.

While the dataset of Arora et al. (2017) provided data for 252 firms of our sample, we had to collect patent data for 131 additional firms. To do so, we followed the methodology of Arora et al. (2017) and sourced data from the PatentsView database of USPTO (https://www.patentsview.org/download/). PatentsView is an initiative of USPTO that makes the patent data available to researchers, covering the population of patents granted by the USPTO from 1976 to date (over 8 million granted patents).

Our process started from obtaining the "Assignee" table. Using the "assignee type" we removed private individuals and governments, resulting in 908,083 assignee organisations. Using Stata's "***matchit***" command (Raffo, 2020), we matched the firm names with Assignee organisation names. The command provides similarity score for similar text patterns. Although PatentsView provides disambiguated data relative to the original USPTO data, some inaccuracies in assignee names remain. Therefore, we first cleaned the name strings from special characters, turned all letters into capitals (because mathcit is case sensitive), and harmonised firm name extensions (incorporated/inc, limited/ltd etc.). We then ran the mathcit command. To minimise false negatives, we made a conservative assumption on the accuracy of matching and kept all matchings with the similarity score of 0.75 and above.

This process resulted in 161,609 name matches. Most of these matches were false positives due to our conservative assumption. In case of an exact match, the similarity score equals 1. For all imperfect matches we proceeded to manual check of the matches for each firm

separately in Excel. Sorting the matches by the ***matchit*** similarity score, in the vast majority of cases manually revising the top 10-20 lines identified all the matchings correctly and exhaustively, hence we could confidently delete the rest of the false-positives. In a small number of cases, we had to go down to 40-50 matches per name. Overall, we manually verified each match before deciding it was a correct matching.

This process enabled us to collect patent data for 90 firms (out of the remaining 131 firms we searched). This meant that we were able to find patents for most firms of our sample (for 342 firms out of 383). Following our matching of 90 firms with assignee ID in the patent dataset, we identified 120,515 patents belonging to 90 firms we were able to match granted in the period of 1980-2014. We provided the split of patents by source and period in the table below.

Period	**Aurora et al**	**PatentsView**	**Total**
1980-2003	99,764	47,748	147,512
2004-2014	186,089	72,767	258,856
	285,853	120,515	406,368