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How can MNEs benefit from internationalizing their R&D across countries with both weak and strong IPR protection?

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ABSTRACT

Although MNEs internationalize their R&D not only in developed countries but also in emerging economies that typically feature weak protection of intellectual property rights (IPR), it remains unclear how this strategic decision affects their productivity performance. This limitation has resulted in a rather incomplete understanding of why some MNEs become more productive through R&D internationalization while others do not. This study develops a new explanation, suggesting that R&D internationalization does not affect the productivity of all MNEs equally because of differences in the idiosyncratic way in which MNEs geographically distribute their R&D units across weak and strong IPR protection countries. In advancing this explanation, the study challenges the view that weak IPR protection is disadvantageous for MNEs by showing that (and specifying how) it: 1) increases the efficacy of MNEs' internal R&D, 2) strengthens the advantages of accessing globally dispersed knowledge, and (3) improves MNEs' ability to exploit cross-country differences in IPR protection. The study enhances understanding of the complex role of IPR protection, shifts scholarly attention from the *degree* of R&D internationalization to *how* MNEs should internationalize their R&D, and clarifies how the IPR context of their location choices matters.

1. Introduction

The extent to which multinational enterprises (MNEs) can leverage location-specific advantages is central to international business (Driffield et al., 2016). R&D internationalization helps MNEs access such advantages and therefore plays a crucial role in enhancing their competitiveness and (productivity) performance (Piperopoulos et al., 2018; Ray and Ray, 2021; Shankar and Narang, 2020; Tojeiro-Rivero, 2022; Xu et al., 2021). MNEs increasingly locate R&D not only in developed countries but also in emerging economies that are characterized by weak protection of intellectual property rights (IPR) (Anand et al., 2021; Belderbos et al., 2021). Doing so

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enables MNEs to source globally dispersed (external) knowledge[1] in such locations and improves the overall effectiveness of technology creation (Kafouros et al., 2022; Un and Rodríguez, 2018; Weitzman, 1998). However, it also increases the difficulty of protecting their technologies from imitation (Brandl et al., 2019; Bruno et al., 2021; Lamin and Ramos, 2016) and may therefore decrease value capture and performance.

Although the literature acknowledges the above advantages and challenges of R&D internationalization (Kim et al., 2020; Papanastassiou et al., 2020; Xu et al., 2021), it remains unclear why some MNEs make location choices that help them become more productive through R&D internationalization while others fail to do so. We suggest that such variations arise because MNEs differ in their strategy of locating R&D units in countries with stronger or weaker IPR protection. Indeed, although the literature has documented the effects of affiliate productivity on parent performance (Driffield et al., 2016), we have a rather incomplete understanding of how the effects of R&D internationalization on MNE productivity are influenced by IPR protection. Specifically, it remains unclear *how MNEs can internationalize their R&D across both weak and strong IPR protection countries in a way that enables them to enhance the efficacy of their own R&D and benefit from globally dispersed knowledge, while reducing the negative effects of weak IPR protection on their productivity performance*.

This study addresses the above question. Its overarching contribution lies in showing that R&D internationalization does not affect the productivity performance of all MNEs equally because they differ in how they geographically distribute their R&D units across weak and strong IPR protection countries. In contrast to studies that focus on one country, our analysis captures each MNE's entire portfolio of R&D units collectively and all its R&D location choices across weak and strong IPR regimes (Kafouros et al., 2022; Kim et al., 2020).

Integrating insights from value appropriation (e.g., Teece, 1986) and evolutionary perspectives (Dosi and Nelson, 1994; Nelson, 2009), our framework shows that IPR protection influences the role of R&D internationalization by affecting three key mechanisms: (1) the efficacy of MNEs' internal R&D – that is, the effectiveness of their own R&D efforts in enhancing productivity performance, (2) their ability to exploit globally dispersed knowledge, and (3) their ability to take advantage of cross-country differences in IPR protection. While prior studies largely focus on the geographic dispersion of R&D, capturing these mechanisms also enables us to examine how MNEs' productivity performance is affected by *IPR heterogeneity* (a construct that has not been examined before). IPR heterogeneity refers to the degree to which an MNE locates its R&D units in countries with *different* strengths of IPR protection. Hence, a higher degree of IPR heterogeneity means that an MNE locates its R&D units in countries with a wider range of IPR strength. It reflects the fact that while some MNEs choose to conduct R&D in *both* strong and weak IPR protection countries (i.e., they make heterogeneous choices regarding IPR regimes), others locate the majority (or even all) of their R&D units in *either* strong *or* weak IPR protection countries (i.e., they make homogeneous choices regarding IPR regimes).

Developing the premise that IPR regimes determine not only technology protection but also how firms access knowledge and what types of knowledge they access (Dosi and Nelson, 1994; Nelson, 2009), we contend that a higher degree of IPR heterogeneity improves MNEs' productivity performance by assisting MNEs to exploit different technology-protection and knowledge-sourcing advantages. We argue that such location-specific advantages cannot be exploited effectively when MNEs' R&D units are located exclusively in countries with similar IPR protection (i.e., an R&D portfolio that is highly dispersed across countries but exhibits a low degree of IPR heterogeneity will be less advantageous).

The study advances our understanding of R&D internationalization in different IPR regimes (Bruno et al., 2021; Papanastassiou et al., 2020; Ray and Ray, 2021) and the performance consequences of such strategic decisions (Deng et al., 2018; Idris et al., 2022; Tojeiro-Rivero, 2022; Un and Rodríguez, 2018; Xu et al., 2021; Yang and Driffield, 2022). First, prior research has typically focused on the degree of R&D internationalization (Hurtado-Torresa et al., 2018) and whether MNEs should locate R&D in weak IPR regimes (Zhao, 2006). Our study offers new theoretical implications by shifting the focus from the degree of R&D internationalization to 'how' MNEs should internationalize their R&D across strong and weak IPR regimes. Second, it challenges the view that weak IPR protection is disadvantageous for MNEs by showing that it enhances both the efficacy of MNEs' internal R&D and their ability to benefit from globally dispersed knowledge (and by specifying the mechanisms through which such effects occur). These insights differ from and complement studies that examine how weak IPR protection affects the use of the firm's own inventions (Zhao, 2006), exploratory innovation (Ray and Ray, 2021) and free riding (Lamin and Ramos, 2016), but do not consider its effects on MNEs' productivity performance.

Finally, our analysis has implications for how international R&D portfolios should be geographically configured for enhancing MNEs' productivity performance. To this end, it develops the construct of IPR heterogeneity and explains how value is created by conducting R&D in a mix of *both* strong and weak IPR protection countries. Our study contributes to IB research on innovation (Idris et al., 2022; Tojeiro-Rivero, 2022; Xu et al., 2021) and the role of location choices (Alcácer and Zhao, 2012; Deng et al., 2018; Yang and Driffield, 2022) by showing how MNEs can configure their R&D portfolios in a way that enhances the advantages of R&D internationalization. It thus underscores the importance of considering IPR protection in all the countries in which the MNE innovates and offers a new explanation of why MNEs differ in their ability to benefit from conducting R&D in strong and weak IPR regimes.

[1] The concept of *globally dispersed external knowledge* rests upon the premise that the R&D activities that various firms and organizations undertake in each country contribute to the society's pool of ideas and specialist knowledge regarding scientific advances and technological developments (Kafouros et al., 2012). Given that some of this knowledge will be relevant and useful to the organization, MNEs that achieve proximal access to such knowledge can source and potentially benefit from it.

2. Theory and conceptual framework

2.1. R&D and productivity performance in MNEs

Productivity performance is a relative notion that depends on the extent to which an MNE succeeds in capturing the value it creates (e.g., through higher revenues).[2] Although productivity performance is in theory jointly determined by value creation and capture, from an empirical point of view we typically observe the net value that the MNE can manage to eventually capture. Nevertheless, although value creation and capture are empirically indistinguishable, it is useful to conceptually differentiate between the two aspects because they can be affected differently.

Although R&D has the potential to create value and increase productivity performance (Driffield et al., 2016), imitation and knowledge leakage (Bruno et al., 2021; Lamin and Ramos, 2016) means that MNEs typically capture (appropriate) only a part of this value (Pisano, 2006; Prud'homme, 2019). According to prior research (Kafouros et al., 2022; Papanastassiou et al., 2020), the value of global R&D is determined by various location-bound characteristics including, for example, the availability of scientific talent, the cost of hiring skilled R&D employees, market size and demand, economic growth, and various institutions pertaining to the effectiveness of government, regulations and legal frameworks. In this study, we focus on the role of the legal framework and, more specifically, on the strength of IPR protection[3] in the countries in which MNEs conduct R&D.

Our conceptual framework builds on two distinct theoretical explanations about the drivers of value creation and capture from R&D (and therefore of productivity performance). The first perspective focuses on the *appropriation* of value (Teece, 1986; Williamson, 2000), whereas the second perspective focuses on the *evolutionary* nature of innovation and R&D (Dosi and Nelson, 1994; Nelson, 2009). While the evolutionary perspective helps us explain how MNEs create value by developing new technologies, the appropriation perspective can help us understand how MNEs capture such value. As firm performance depends on both value creation and value capture (and both are influenced by IPR protection), each perspective provides a partial account of how IPR protection affects MNEs' productivity performance. Therefore, combining the two perspectives is theoretically useful as they complement one another in explaining the effects of IPR protection more holistically. The next sections discuss these two perspectives in detail.

2.2. Value appropriation perspectives

Value appropriation perspectives rely on the premise that enhancing productivity performance requires an MNE to capture (appropriate) value from the technologies and inventions it creates through its R&D activities. This view implies that an MNE should conduct R&D in environments that protect its inventions from imitation and unauthorised use (Teece, 1986; Kafouros et al., 2021). Although technological complexity and the possession of co-specialized assets can help MNEs reduce imitation from rivals, IPR laws play a crucial role in helping MNEs capture a larger share of the value that is created from R&D (Teece, 1986; Williamson, 2000) and increase their productivity performance (Kafouros et al., 2021).

A strong legal framework and the enforcement of IPR laws provide two distinct advantages that can increase value appropriation from R&D. First, MNEs can increase the returns to their R&D by taking legal action against rivals that infringe on their proprietary technologies (Kafouros et al., 2021). Strong IPR protection reduces the likelihood that the technologies of an MNE will be imitated or used without contractual agreement (Williamson, 2000). Second, strong IPR regimes facilitate collaboration and enhance partners' commitment by defining each their rights and responsibilities (North, 1991). They therefore improve the functioning of markets for technologies and widen the scope of contractual agreements (Williamson, 2000), thus improving the value an MNE can capture from its R&D efforts.

2.3. Evolutionary perspectives

Evolutional perspectives of technological and economic change focus on the creative process itself (Nelson and Winter, 1982; Singh and Fleming, 2010). They view technology creation as an evolutionary combinatorial process that is driven by three interrelated phases: variation, selection and retention. The variation phase involves the creation of new ideas, knowledge and technologies through the *sequential accumulation* and (*re*)*combination* of existing ideas, knowledge and technologies. The selection phase involves the assessment of such ideas, knowledge and technologies with the aim of identifying those with the greatest potential. In the retention phase, a subset of the most effective ideas and technologies is adopted (i.e., the best technologies are *utilized* to a greater extent) (Singh and Fleming, 2010).

Evolutionary perspectives are useful for explaining how knowledge accumulation leads to technological evolution and enables organizations to conduct R&D more effectively (Dosi and Nelson, 1994). As knowledge builds upon itself, the creation of new technologies and their evolution are seen as a direct function of (re)combining existing knowledge and technologies (Weitzman, 1998; Carnabuci and Operti, 2013). Given the importance of identifying and making useful combinations, evolutionary perspectives postulate that technological development relies on the sequential accumulation (or build-up) of scientific and technical knowledge

[2] Value in our paper and prior studies is typically captured by the revenue that an MNE can generate from using and commercializing its technologies in the market (adjusted for intermediate costs).

[3] IPR protection refers to the effectiveness of legal, regulatory and political institutions of each country in protecting the owners of intellectual property from imitation by rival organizations (Park, 2008).

(Bessen and Maskin, 2009). Hence, easier and less costly access to a large and diverse knowledge pool is critical, leading to the creation of valuable ideas and discoveries (Bessen and Maskin, 2009; Kafouros et al., 2022; Un and Rodríguez, 2018).

In sum, the evolutionary theory highlights that the effectiveness of variation, selection and retention (and thus the effectiveness of R&D) is driven by the extent to which the environment enables the 1) *utilization*, 2) *sequential accumulation* and 3) (*re*)*combination* of knowledge and technology. The next section develops hypotheses that clarify how IPR (in)effectiveness influences these three mechanisms and, in turn, productivity performance.

3. Conceptual framework and hypotheses

Integrating theoretical insights from the value appropriation perspective and the three key mechanisms of the evolutionary perspective (the utilization, sequential accumulation and (re)combination of knowledge and technology), our framework recognizes that cross-country differences in the strength of IPR protection represent both advantages and challenges for MNEs that internationalize their R&D. Accordingly, the next two sections develop two hypotheses that clarify the effects of IPR protection on MNEs' ability to benefit from globally dispersed knowledge (H1), and on the efficacy of MNEs' internal R&D (H2). The last section considers how the dispersion of R&D units across *both* strong and weak IPR protection countries (a concept we refer to as IPR heterogeneity) can help MNEs manage the associated challenges and advantages (H3). Given that MNEs possess multiple interdependent R&D units (Papanastassiou et al., 2020), we capture the entire portfolio of R&D units for each MNE.

3.1. IPR protection and globally dispersed knowledge

The benefits of sourcing external knowledge from abroad are significant (Asimakopoulos et al., 2020; Driffield et al., 2016). R&D units can identify and transmit relevant technical knowledge and information on new promising activities (Maskell, 2014). Internal linkages facilitate knowledge transfer between the MNE's units and strengthen technological interdependencies within the organization (Alcácer and Zhao, 2012). Therefore, a global portfolio of R&D units can serve as a vehicle for transferring and integrating technological knowledge (Xu et al., 2021). As the invention-based perspective of the MNE postulates (Kafouros et al., 2022), such benefits lead to the co-creation of technology, new scientific breakthroughs and stronger MNE performance. Although the literature has recognized these knowledge sourcing advantages (Maskell, 2014), it is unclear how IPR protection across countries moderates the ability of MNEs with international R&D to benefit from globally dispersed knowledge. The first hypothesis focuses on this relationship.

Our analysis considers not only the knowledge that is held at the MNE's home country, but also the knowledge that can be accessed from other countries in which the MNE locates its R&D units (Kafouros et al., 2012). Although it is difficult to identify in detail what kind of knowledge each R&D unit in different locations can source, both developed and emerging economies can provide a rich pool of knowledge. Because many emerging economies are large and have significantly increased their R&D spending, they have built knowledge pools that are considerably larger than those of many developed countries. Using R&D units as listening posts (Maskell, 2014; Papanastassiou et al., 2020), MNEs can exploit location-specific knowledge not only from their own immediate technological area but also from other distinct domains (Kafouros et al., 2012). Building on this premise and the key mechanisms discussed earlier (*utilization, sequential accumulation* and *re-combination*), our first hypothesis posits that R&D portfolios that have a higher share of countries with weaker IPR protection increase MNEs' ability to benefit from such knowledge and increase their productivity performance.

Countries with stronger IPR protection reduce uncertainty and improve coordination, incentivizing MNEs to engage in R&D. However, stronger IPR protection decreases the extent to which organizations can utilize and combine external ideas and technologies. By contrast, weaker IPR protection accelerates technological diffusion and knowledge spillovers (Nandkumar and Srikanth, 2016), creates a wider set of technological opportunities, and facilitates the diffusion of practices that stimulate novel combinations (Maskell, 2014; Winter, 1993). It also enables MNEs to identify ample opportunities to learn about scientific advances from universities, improve processes with suppliers, understand market preferences from customers and access their competitors' designs (Asimakopoulos et al., 2020). Furthermore, conducting R&D in weak IPR protection countries helps MNEs not only to access and combine knowledge that complements that from strong IPR regimes, but also learn about different approaches to innovation (e.g., low-cost frugal innovations) that cannot be learnt in strong IPR regimes (Shankar and Narang, 2020). Therefore, by providing the MNE with different competitive advantages and access to diverse knowledge, weaker IPR protection enhances the utilization of external knowledge and the usefulness of the external innovation ecosystem in which the MNE can draw from Bessen and Maskin (2009) and Inkpen et al. (2019).

The evolutionary perspective reinforces the above reasoning, suggesting that firms may generate more economic value (Dosi et al., 2006) and a higher surplus from their technologies in weaker (rather than stronger) IPR regimes (Winter, 1993). The disclosure of knowledge (e.g., from patents) is particularly important in accelerating knowledge diffusion. It makes prior technological advances an important determinant for future inventions (Baruffaldi and Simeth, 2020), accelerating the rate of sequential accumulation. By contrast, strong IPR protection limits technological diffusion and raises the difficulty of accessing external knowledge and technology (Dosi et al., 2006; Fleming and Sorenson, 2001). Hence, it results in the underutilization of external technologies, i.e., existing ideas and technologies in each innovation ecosystem are not utilized to their full potential (Heller and Eisenberg, 1998). This, in turn, may push MNEs to make sub-optimal technological choices – i.e., it may limit MNEs' ability to follow the most optimal path when developing new technologies because it prevents them from using the most beneficial technologies and knowledge (Moser, 2013).

Furthermore, weaker IPR protection reduces the costs of accessing not only involuntary knowledge spillovers but also external proprietary technology through licencing and other contractual agreements. Lighter penalties for infringing property rights in weak IPR regimes (Kafouros et al., 2021; Wang et al., 2020) reduce the bargaining power of technology owners who often reduce the licencing fees for their technologies to avoid opportunistic behaviour. Hence, although it is more difficult for MNEs to protect their own technologies, such environments enable them to access technology at a lower cost than what it would have been in countries with strong IPR regimes. This improves the sequential accumulation and utilization of knowledge, helps MNEs combine external technologies more effectively, and therefore enhances its impact on MNEs' productivity performance. Hence, we expect locating a higher share of an MNE's R&D portfolio in weaker IPR protection countries to strengthen the effects of globally dispersed knowledge on its productivity performance:

Hypothesis 1. The higher the share of countries with weaker IPR protection in an MNE's R&D portfolio, the stronger the effects of globally dispersed knowledge on its productivity performance.

3.2. IPR protection and the efficacy of internal R&D

Building on research that examined how MNEs leverage locational advantages to enhance their performance (Yang and Driffield, 2022), our next hypothesis proposes that weaker IPR protection strengthens the efficacy of an MNE's internal R&D (i.e., the effectiveness of R&D in enhancing its productivity performance). This prediction hinges, once again, on how the strength of IPR protection affects the utilization, sequential accumulation and re-combination of knowledge and technology.

As discussed earlier, technology creation builds cumulatively on predecessor technologies (Bessen and Maskin, 2009; Weitzman, 1998). Therefore, the effectiveness of an MNE's internal R&D depends on the degree to which it can utilize external technologies in a sequential manner and use them as platforms for developing new ones (Fleming and Sorenson, 2001; Kim et al., 2020). Greater exposure to external technologies helps MNEs improve inefficiency in their innovation activities and utilize internal resources more effectively (Asimakopoulos et al., 2020). Given that weaker IPR protection facilitates such exposure, R&D teams can utilize prior technologies more easily (Carnabuci and Operti, 2013; Weitzman, 1998), thus improving the effectiveness of an MNE's R&D in enhancing its productivity. By contrast, strong IPR protection may hinder R&D by increasing the difficulty of creating better or different versions of follow-up technologies (Brandl et al., 2019).

Insights from the invention-based view of the MNE reinforce the above reasoning (Kafouros et al., 2022). New technologies emerge from the novel (re)combination and reconfiguration of diverse technological components (Carnabuci and Operti, 2013; Kim et al., 2020). By influencing variation and selection mechanisms, IPR regimes determine not only technological advance, but also the trajectory and direction of technological advance. As weaker IPR regimes offer diversity in stimuli that improves such variation and selection processes, they help R&D teams increase the number of recombinant opportunities (Singh and Fleming, 2010). By offering easier and less restricted access to external technologies and a context that differs from that in developed countries (Xu et al., 2021; Yang and Driffield, 2022), weaker IPR protection allows MNEs to identify technological opportunities and paths that cannot be found or pursued easily in stronger IPR regimes. This strengthens the R&D capabilities of firms (Asimakopoulos et al., 2020; Maskell, 2014) and increases the likelihood of coming up with novel value-enhancing technological combinations (Kafouros et al., 2022). Similarly, different sets of experiences and knowledge makes selection processes in R&D teams more rigorous and efficient as they assist in assessing a larger number of potential options and from different points of view. Hence, weaker IPR protection can unlock the potential of MNEs' R&D and therefore its impact on productivity performance.

In summary, although we do not expect that weaker IPR regimes can directly increase productivity, we predict that they improve the R&D capabilities of MNEs by making access to new opportunities, technologies and their constituent components easier and less costly, facilitating the effective utilization and combination of existing technologies, and allowing MNEs to choose more optimal technological trajectories. Hence:

Hypothesis 2. The higher the share of countries with weaker IPR protection in an MNE's R&D portfolio, the stronger the effectiveness of its own R&D in improving its productivity performance.

3.3. IPR heterogeneity in international R&D portfolios

3.3.1. Geographic dispersion of R&D portfolios

While some MNEs disperse their R&D units widely across many countries, others concentrate them in few countries only. While the geographic dispersion of R&D units increases the challenges of coordination, control and knowledge leakage (Kafouros et al., 2022; Papanastassiou et al., 2020), it provides two key advantages in terms of 1) knowledge sourcing and 2) technology protection. First, the geographic dispersion of R&D is a strategic decision that can have a profound effect on MNEs' ability to create value from technology by sourcing location-specific diverse knowledge and technologies (Leiponen and Helfat, 2011; Luo et al., 2021). The global dispersion of R&D units can help MNEs to access, transfer and integrate location-bound knowledge from completely different locations (Xu et al., 2021). This represents a significant *knowledge-sourcing advantage* over MNEs that conduct R&D in few locations (or even in one location only).

In addition to its knowledge-sourcing advantage, geographic dispersion can also be used by MNEs as a *technology-protection mechanism* to increase value capture (Zhao, 2006). Innovation requires the combination and integration of several technological components that often reside in different countries (Fleming and Sorenson, 2001; Kafouros et al., 2022). This means that each technology alone has limited functionality and value unless it is combined with other technologies and assets that are held in different parts of the MNE (Zhao, 2006). Given that MNEs appropriate more value when they can limit imitation by rivals (Alcácer and Zhao, 2012; Kafouros et al., 2021), dispersing R&D across many countries helps MNEs create barriers to imitation by increasing the difficulty and costs for imitators (as they need to steal technology from multiple and often distant R&D units). Hence, given that technology development is dispersed across an MNE's multiple R&D locations and it is firm-specific in its intended use (Nelson and Winter, 1982), geographic dispersion can reduce the likelihood of knowledge outflows while increasing the barriers to imitation even in weak IPR regimes (Alcácer and Zhao, 2012; Kim, 2016).

In summary, prior insights suggest that while the geographic dispersion of R&D poses certain coordination, control and knowledge-leakage challenges, it assists MNEs in accessing valuable knowledge and creating barriers to imitation.

3.3.2. IPR heterogeneity in R&D portfolios

Extant theory on diversity (Harrison and Klein, 2007) suggests that a key aspect of diversity is 'separation', which refers to the fact that certain differences lead to dissimilarities (heterogeneity) in a particular value. Building on this view, we posit that *IPR heterogeneity* in R&D portfolios (i.e., conducting R&D in *both* strong and weak IPR protection countries) can help MNEs deal with certain challenges and improve the utilization, sequential accumulation and (re)combination of knowledge and technology. Specifically, we hypothesize that IPR heterogeneity enhances productivity performance by providing MNEs with both *knowledge sourcing* and *technology protection* advantages that go beyond the advantages of mere geographic dispersion. We expect such advantages to differ between R&D portfolios that are characterized by a higher degree of IPR heterogeneity and those that are dominated by *either* strong *or* weak IPR protection countries.

To understand this prediction, we must first clarify how *IPR heterogeneity* differs from *geographic dispersion*. Although it might seem intuitive to presume that greater geographic dispersion of R&D might result in a higher level of IPR heterogeneity, the two constructs are not positively correlated in practice.[4] For instance, an MNE can disperse its R&D units across a large number of countries but choose to locate the majority or even all of its R&D units in countries with either strong or weak IPR protection (i.e., make a homogeneous choice regarding IPR protection), resulting in a lower degree of IPR heterogeneity. Hence, a higher degree of geographic dispersion does not necessarily mean that IPR heterogeneity will also be high. The opposite may also occur. For instance, an MNE that conducts R&D in few countries only can still achieve a higher degree of IPR heterogeneity by choosing countries that differ considerably in IPR protection.

Given that geographic dispersion and IPR heterogeneity are two conceptually distinct constructs, we expect the technology protection and knowledge sourcing advantages of IPR heterogeneity to differ from those obtained from mere geographic dispersion. First, the knowledge and overall advantages of weak IPR regimes (e.g., in emerging economies) differ considerably from those of strong IPR regimes (typically in developed countries) (Piperopoulos et al., 2018; Yang and Driffield, 2022). The context in which firms innovate leads to different trajectories of technological development and therefore affects the type of knowledge that is created in each regime (Wang et al., 2020). Hence, IPR regimes determine not only whether access to external technological knowledge will be easier and less costly for firms, but also what type of knowledge firms can access and utilize (Nelson, 2009). As a higher degree of IPR heterogeneity allows MNEs to access and combine a completely different set of knowledge and inputs from both weak and strong IPR regimes, it assists MNEs in coming up with useful combinations (Davis and Aggarwal, 2020; Ehls et al., 2020), thus enhancing their productivity performance.

For example, countries with weaker IPR regimes, such as India and China, have accumulated knowledge about how to utilize, combine and transform less radical technologies (Piperopoulos et al., 2018), develop cost-saving and frugal innovations that reduce the price of products, and develop solutions for resource-constrained environments (Shankar and Narang, 2020). By contrast, countries with strong IPR protection, such as the USA and the UK, are endowed with knowledge about the development of frontier technologies that require state-of-the-art scientific research. Hence, IPR heterogeneity in an MNE's R&D portfolio enables the organization to exploit such diversity in the characteristics of knowledge, access environments that differ in the nature of innovation, and utilize and combine a set of rather different technological inputs. This, in turn, helps MNEs create novel combinations (Kim et al., 2020) that have greater potential to generate value and increase productivity performance.

Second, depending on the nature and purpose of each technology, it is more effective to develop certain technologies (e.g., those that push technological frontiers or those that can be imitated easily) in strong IPR protection countries and other technologies (e.g., those that involve adaptation and refinement or heavily rely on external knowledge) in weak IPR protection countries. In such cases, IPR heterogeneity provides significant advantages by facilitating the optimal dispersion of R&D efforts across countries depending on which IPR regime is more advantageous and appropriate for each technology and R&D project (Kafouros et al., 2022). MNEs will not be able to realize these advantages when the degree of IPR heterogeneity of their R&D portfolio is lower and conduct all or most of their R&D in countries with *either* strong *or* weak IPR protection (rather than a mix of the two). This limits their ability to exploit different location-specific advantages associated with each IPR regime and may therefore have a negative effect on their productivity performance.

Finally, building on research concerning the role of location choices (Alcácer and Zhao, 2012; Kafouros et al., 2012), we expect locating most or all of the MNE's R&D units in countries with weak IPR protection to be less beneficial. MNEs often disperse the development of technological components across several weak IPR protection countries (to access and combine diverse knowledge). However, when they integrate such components to create functional technologies, the literature suggests that MNEs must choose a strong IPR protection country because if imitation occurs, it can be particularly detrimental in such cases (Zhao, 2006). Hence, R&D portfolios that do not include strong IPR protection countries will be less advantageous for enhancing MNEs' performance.

Equally, the opposite strategy (i.e., locating most or all of their R&D units in countries with strong IPR protection) is less beneficial

[4] Indeed, according to the descriptive statistics in Table 2, the two constructs are negatively correlated (−0.52).

as well. Although this strategy may allow MNEs to protect their technologies, it reduces the knowledge-sourcing advantages discussed earlier. This is detrimental for MNE performance, particularly when MNEs' innovative activities rely on externally sourced ideas (Kafouros et al., 2022; Leiponen and Helfat, 2011). Hence, both strategies (locating all R&D units in either weak or strong IPR protection countries) lead to imbalances between protecting technology and accessing global knowledge and therefore are not conducive to enhancing MNEs' productivity performance.

In sum, IPR heterogeneity in R&D portfolios serves both as a technology-protection mechanism and as a mechanism that facilitates knowledge-specific advantages. Accordingly, we expect that R&D portfolios that consist of countries of various strengths of IPR protection to be more effective in enhancing MNEs' productivity performance than R&D portfolios that focus largely on countries with *either* weak *or* strong IPR protection only:

Hypothesis 3. For a given level of geographic dispersion, the higher the degree of IPR heterogeneity in an MNE's R&D portfolio, the stronger the MNE's productivity performance.

4. Methods

4.1. Data sources

We identified UK manufacturing MNEs that conduct global R&D from Thomson One Banker. We collected information concerning the location and number of each MNE's home and overseas R&D units from annual reports, corporate websites, and telephone interviews. This process provided a comprehensive coverage of the geographic structure and location choices of the R&D portfolio of each MNE for a period of 5 years (2004–2008). It resulted in a panel dataset comprising of 564 R&D units that are owned by 74 MNEs from industries such as aerospace, chemicals, computer, electrical components and equipment, drugs, electronics, food, household products, machinery, metal manufacturers and textiles. The dataset covers the period of 2004–2008 providing 370 observations at the MNE level and 2820 R&D-unit-year observations. The R&D units of the sampled MNEs are dispersed across 47 countries (Table 1). To this end, we supplemented MNE-level data with country-industry-specific information for the 47 countries of the sample from various databases; namely, the World Bank, the OECD Analytical Database, the World Development Indicators and the World Governance Indicators of the World Bank, a database developed by the Union Bank of Switzerland (2006, 2009, 2015), and indices developed by Ginarte and Park (1997) and Park (2008).

4.2. Dependent variable

As our framework focuses on productivity performance, we employed the commonly used measure of Total Factor Productivity (TFP) (Kafouros et al., 2012; Wang et al., 2012a). Following established practice, we estimate TFP as a ‘residual’ that captures increases in output (revenue) that cannot be explained by variations in input factors such as capital (total assets), labor (employees) and intermediate materials. Hence, the measure reflects the ability of MNEs to create and capture value from a given set of inputs.

TFP is widely used for two key reasons. First, it captures the different benefits of R&D. Product innovations increase revenues, whereas process innovations decrease costs and improve efficiency. As TFP captures both revenues and costs, it is more effective than measures that merely reflect technological success (e.g., patent output). Second, the fact that it captures both revenues and the cost of intermediate inputs means that it reflects various advantages (e.g., accessing external knowledge and low-cost scientific talent), while avoiding biases that are caused because different outputs exhibit different economies of scale.

The estimation of TFP in the literature has largely relied on three different methods: ordinary least squares (OLS), fixed effects (FE), and a semi-parametric approach developed by Levinsohn and Petrin (2003) (Lev-Pet) (Wang et al., 2012a). Estimating the TFP residuals using OLS may lead to simultaneity bias by treating capital and labor as exogenous (Levinsohn and Petrin, 2003). Given the difficulty of accounting for this problem (Wang et al., 2012a), we estimate TFP using FE which is particularly appropriate for our research context that includes different locations, sectors and MNEs. Nevertheless, we also estimate TPF using the Lev-Pet approach as a robustness test (described in the Results section).

Table 1
Locations of R&D units.

Country	R&D units	Country	R&D units	Country	R&D units	Country	R&D units
Argentina	1	Korea	3	Finland	2	Slovenia	1
Australia	21	Luxembourg	2	France	35	South Africa	7
Austria	2	Malaysia	3	Germany	33	Spain	6
Belgium	8	Mexico	3	Greece	1	Sweden	13
Brazil	4	Netherlands	11	Hong Kong	7	Switzerland	8
Bulgaria	1	Norway	10	Hungary	1	Taiwan	1
Canada	16	Philippines	1	India	18	Thailand	2
Chile	2	Poland	5	Indonesia	2	UK	123
China	14	Portugal	1	Ireland	6	United Arab Emirates	2
Croatia	2	Russia	3	Italy	9	USA	132
Czech Republic	5	Saudi Arabia	5	Japan	12	Vietnam	3
Denmark	7	Singapore	8	Jordan	2		

4.3. Key independent variables

4.3.1. MNE R&D

We measure each MNE's stock of R&D using the perpetual inventory method that accounts for the MNE's current and past R&D investments. We depreciated R&D by 20 % annually.

4.3.2. Globally dispersed knowledge

To measure the external knowledge that an MNE can access through its R&D units, we used the perpetual inventory method to estimate industry-country-specific knowledge pools for each year. We collected information on the R&D conducted by all organizations in each industry and country from the OECD Analytical Database. We then matched the countries in which a focal MNE has established R&D units to the industry-specific knowledge pools residing in these locations (we used up to 4-year lags). We constructed (1) intra-industry knowledge pools for the MNE's key industry and (2) inter-industry knowledge pools for other industries. Using Eq. (1) and the aggregate R&D (*RD*) in each industry (*y*), we estimated the intra-industry knowledge pool (*KnowPool*) accessible to an MNE (*i*) at time (*t*) (*k* represents the lagged year and δ the depreciation). We conducted these estimations for each industry and country.

$$KnowPool_{intra,it} = RD_{yt} + \sum_{1}^{k} (1-\delta)^k RD_{y(t-k)} \tag{1}$$

We then developed a matrix that measures the industrial distance between sectors—i.e., the extent to which MNEs in each industry (*y*) use the products, knowledge, and technologies of another industry (*j*). Using input–output data on the use of 122 types of inputs, we constructed a proximity matrix (*W*) that represents the distance (relevance) between sectors. Using this matrix and Eq. (2), we operationalize the inter-industry knowledge pools accessible to MNE ***i*** as the weighted sum of the different industry-specific knowledge pools (*P*) in the countries in which it has R&D units. We repeated this process for each industry and country, estimating 3525 knowledge pools for the 47 countries of the sample.

$$KnowPool_{inter,i} = \sum_{j=1}^{n} WijP_j \tag{2}$$

4.3.3. Ineffective IPR protection in the MNE's R&D portfolio

We inversed the indices developed by Ginarte and Park (1997) and Park (2008) to estimate *ineffective* (*weak*) *IPR protection*. Hence, a higher value of the measure indicates weaker (less effective) IPR protection. This composite index captures various dimensions of protection, including legal enforcement, patentability, duration, treaties, licencing restrictions and other patent rights. As each MNE's R&D units are located in multiple countries, we use the mean value of IPR protection for those countries.

4.3.4. IPR heterogeneity in the MNE's R&D portfolio

Building on prior studies (Oxley and Sampson, 2004; Vassolo et al., 2004), we estimate IPR-heterogeneity in each MNE's R&D portfolio by measuring the extent to which IPR protection in each country differs from that of other countries in its portfolio. We estimated IPR differences not only between the home and host country but also between all the countries in which the MNE has located R&D units. Hence, the measure does not represent merely the distance between home and host countries. Instead, it captures dissimilarities in IPR across all the R&D locations in an MNE's portfolio (Harrison and Klein, 2007). To do so, we initially use Park's (2008) index to categorize each country's strength of IPR protection into low, medium, and high. We avoided using a continuous IPR measure because our hypotheses concern the differences between stronger and weaker regimes, rather than the 'distance' between them. We then identified all the dyadic combinations of R&D locations for each MNE and estimated the extent to which each combination differs in IPR protection. For example, if two R&D units both operate in countries with weak IPR protection, then these location choices are categorized as being similar (and vice versa). As MNEs have several R&D units, we estimated this measure for every possible dyadic combination of units in the MNEs' R&D portfolio and for each year separately to capture changes over time (e.g., an MNE with 4 R&D units will have 6 dyadic combinations per year). This process resulted in a portfolio-specific measure for each MNE based on the mean of all possible dyadic combinations within an MNE's R&D portfolio. As large MNEs typically have many R&D units, we divided the measure by the total number of R&D units in each portfolio. Higher values of the measure represent location choices that differ in IPR protection (i.e., there is a mix of weak and strong IPR regimes in the portfolio).

4.4. Control variables

4.4.1. Geographic dispersion in the MNE's R&D portfolio

To ensure that our estimates are not biased by the geographic dispersion of each R&D portfolio, we capture the choice of MNEs to locate R&D units across many (or few) countries. To operationalize the dispersion of an MNE's R&D portfolio, we identify the number of different countries in which the MNE conducts R&D in each given year.

4.4.2. Internationalization of R&D portfolio

Although there is no consensus regarding the performance effects of R&D internationalization, it is imperative to control for it. This variable is operationalized using the number of the MNE's overseas R&D units. As larger MNEs are likely to have many R&D units, we estimated the ratio of overseas R&D units to the total number of R&D units to normalize for size.

4.4.3. Internationalization experience (sales and assets)

Highly internationalized MNEs that have greater experience in foreign markets may perform differently from those that are less internationalized and experienced. We therefore control for the internationalization of MNEs' sales using the ratio of *Foreign Sales to Total Sales* (*FSTS*). Furthermore, we control for *Foreign Assets to Total Assets* (*FATA*) to capture the fact that some MNEs have got a higher (or lower) level of assets located abroad compared to other MNEs.

4.4.4. MNE size

We control for MNE size using a dummy variable that separates larger from smaller MNEs at the median level of revenues. We avoided including a continuous measure of revenues because it is used in the estimation of TFP.

4.4.5. Product diversification

As product diversification may influence performance, we include the commonly used entropy measure (Delios and Beamish, 1999) based on the number of product segments in which an MNE competes (at the 3-digit SIC classification).

4.4.6. MNE profitability

To control for MNE profitability, we incorporate a measure of "earnings before interest and tax". As profitability can be measured in different ways, we also use alternative profitability measures (return of assets, operating profit margin, operating income), which are reported in robustness tests section.

4.4.7. MNE age

Using data on the founding year of each MNE, we incorporated a new variable to capture its age (measured as current year minus the founding year).

4.4.8. Country-specific cost of scientific labor

The largest component of R&D costs is the cost of hiring R&D personnel, which varies widely from country to country. We identified information on such costs from the Union Bank of Switzerland survey of International Wage Comparison (Union Bank of Switzerland, 2006, 2009, 2015). We used the annual cost for hiring scientists and engineers in each country that captures their wages as well as indirect costs, such as bonuses and allowances. We estimated the variable separately for each MNE by calculating the average cost for all the countries in which the MNE conducts R&D.

4.4.9. Country-specific demand

Countries differ in their market size, which may affect the value and feasibility of conducting R&D. Market demand in each country may also influence economies of scale and MNEs' ability to perform certain market-specific functions that improve R&D effectiveness. To capture host-country demand, we used data on gross domestic product (GDP) from the World Bank.

4.4.10. Country-specific level of education

Countries differ in education systems and the availability of educated staff, which might affect the ability of MNEs to recruit talent for their R&D units. The model controls for such variations by incorporating the *number of graduates per million people* in each country. This measure is portfolio-specific (i.e., it accounts for all the countries in which the MNE conducts R&D).

4.4.11. Emerging economies vs. developed counties

R&D and innovation in emerging economies is often qualitatively different from R&D and innovation in developed countries. We accordingly control for each MNE's tendency to locate its R&D in emerging economies. This portfolio-specific measure is estimated using the number of an MNE's R&D units in emerging economies over the total number of its R&D units. Hence, the higher the value of the measure, the higher the MNE's tendency to locate R&D in emerging economies.

4.4.12. Country economic growth

To control for variations in economic growth, we use the average annual growth rate of the countries in which each MNE conducts R&D.

4.4.13. Political/government effectiveness

To control for variations in government effectiveness across countries, we used the World's Bank Worldwide Governance Indicators (WGI). WGI gathers information about the quality of public services and civil services, its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. WGI ranks each country from 0 to 100. Therefore, the higher the score, the higher the government effectiveness.

4.4.14. Time and industry

Finally, we include dummy variables for each year and industry to capture year-specific and industry-specific idiosyncrasies.

4.5. Regression analysis

The Wooldridge (2010) test shows that first-order autocorrelation is present in our panel data, making the use of OLS less appropriate. Furthermore, autocorrelation differs across industries, causing panel-specific first-order autocorrelation in our data (confirmed by the likelihood ratio test; Cheng and Nault, 2007). The likelihood ratio test also shows that the variance of the disturbance term is heteroscedastic across panels. To address these issues, we employed the commonly-used feasible generalized least squares (FGLS) estimator for panel data (Cheng and Nault, 2007; Lu and Beamish, 2004). FGLS is effective for our research context because it produces efficient and consistent results when the disturbances of the model are not independent and identically distributed (Wooldridge, 2010). We used the logarithm of the variables to improve the interpretation of the results.

5. Results

5.1. Regression results

Table 2 reports the descriptive statistics and Table 3 reports the regression results. Model 1 is a baseline model while Models 2, 3 and 4 test hypotheses H1, H2 and H3, respectively. Model 2 includes an interaction term between globally dispersed knowledge and ineffectiveness of IPR protection. This interaction term is positive and highly statistically significant, providing support for H1. It indicates that although globally dispersed knowledge may on average benefit all firms, locating R&D units in weaker IPR regimes strengthens these effects on productivity performance. Put differently, the productivity-enhancing advantages of globally dispersed knowledge increase when a higher share of an MNE's R&D portfolio is located in counties with weaker IPR protection. A similar pattern is observed in Model 3 that introduces a term for each MNE's R&D and its interaction with ineffective IPR protection (thus testing H2). The interaction term between an MNE's own R&D and ineffective IPR protection is positive and statistically significant. These results support H2, suggesting that locating R&D units in countries with weak IPR protection enhances MNEs' productivity performance through their own R&D efforts.

To understand the interaction effects of H1 and H2, Figs. 1 and 2 depict the predicted margins for these effects; i.e., they show how productivity performance is influenced by globally dispersed knowledge and R&D respectively at different strengths of IPR protection. The dashed lines represent the average strength of IPR protection while the solid lines show how those effects change when IPR protection is ineffective. Figs. 1 and 2 confirm the predictions of H1 and H2 as the solid lines in both figures are much steeper than the dashed lines (i.e., they show that globally dispersed knowledge and R&D increase productivity performance more strongly when IPR protection is ineffective). Given that these variables are expressed in logs, it is worth noting that the benefits are considerable for globally dispersed knowledge (the coefficient of the direct effect is 0.276 and the interaction effect is much higher at 1.189) as well as for R&D (its direct effect is 0.392 and the interaction effect is once again much higher at 0.843). Overall, the results suggest that MNEs benefit from locating R&D in countries with richer knowledge pools, these effects on MNEs' productivity are strengthened when IPR protection is weaker.

Finally, Model 4 tests the role of *IPR heterogeneity* (i.e., H3). Given the importance of capturing the effects of IPR heterogeneity after accounting for the effects of geographic dispersion, Model 4 includes IPR heterogeneity as well as geographic dispersion and its interaction with ineffective IPR protection. Hence, Model 4 ensures that these effects are not merely driven by the dispersion of R&D units across many countries. The results support H3, indicating that IPR heterogeneity improves productivity performance. Hence, R&D portfolios that include a mix of countries with both strong and weak IPR regimes are more effective in enhancing MNE performance than those that are dominated by either strong or weak IPR regimes. Interestingly, although the literature often presumes that geographic dispersion is beneficial (as it helps MNEs to deal with imitation), the interaction term between geographic dispersion and ineffectiveness of IPR protection is negative and does not confirm this view.

5.2. Robustness checks

We conducted various checks to rule out alternative explanations of the results. First, we estimated the residuals of TFP using the OLS and the Lev-Pet method (rather than the FE approach). One of the key benefits of the Lev-Pet approach is that it uses intermediate inputs (materials) to proxy for unobservable productivity shocks and deal with potential simultaneity (Levinsohn and Petrin, 2003). Models 5 and 6 in Table 3 report these results. The results of the OLS approach in Model 5 are similar to the FE results and support all the hypotheses. In the case of the Lev-Pet approach (Model 6), the results are similar to those reported in Model 4 and, once again, support the hypotheses (except for the coefficient for H1 that became statistically insignificant). We have also experimented with Sales as dependent variable (instead of TFP). The results (not shown in the table) are similar to those in Model 4 except for the coefficient for H1 which is statistically insignificant.

Second, we considered potential cofounding effects that may arise due to the correlation between the (in)effectiveness of IPR protection and cost of R&D, which is fairly high and may bias the results. Although dropping one of the variables may address such concern, this solution is not theoretically justified. We therefore used the residual centering procedure for orthogonalizing variables. This consists of two stages: a) regressing the IPR-protection variable on the cost of R&D and b) including the residuals in the model (instead of the initial R&D cost variable). This procedure yielded similar results. Nevertheless, to ensure that the results are not affected by high correlations, we have also re-estimated the models after removing various independent variables that were correlated with each other, including country-specific education, country-specific cost of scientific labor, emerging to developed countries and country-specific economic growth. The new results were similar to the results presented in Table 3, confirming the hypothesized

Table 2
Descriptive statistics and correlations.

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. MNE productivity	0.00	0.57																		
2. IPR heterogeneity	7.99	2.07	−0.04																	
3. R&D	−1.70	0.64	0.258*	−0.06																
4. Globally dispersed knowledge	4.30	0.42	0.02	−0.267*	0.248*															
5. Ineffectiveness of IPR protection	−0.35	0.16	−0.09	−0.04	−0.403*	−0.289*														
6. Geographic dispersion of R&D	5.41	3.36	−0.06	−0.525*	−0.340*	0.273*	0.559*													
7. Internationalization of R&D	−0.16	0.13	0.118*	−0.212*	−0.279*	0.242*	0.348*	0.557*												
8. MNE Profitability	3.37	3.28	0.384*	−0.209*	−0.323*	0.05	0.245*	0.322*	0.287*											
9. Internationalization of sales	−0.30	0.33	0.10	−0.146*	−0.220*	0.10	0.105*	0.280*	0.381*	0.221*										
10. Internationalization of assets	1.46	0.48	0.05	−0.158*	−0.243*	0.04	0.202*	0.253*	0.362*	0.250*	0.506*									
11. MNE size	0.64	0.48	0.144*	−0.278*	−0.405*	−0.06	0.429*	0.448*	0.471*	0.602*	0.193*	0.346*								
12. Product diversification	0.74	0.61	0.112*	−0.04	−0.437*	−0.201*	0.267*	0.215*	0.107*	0.402*	0.105*	0.172*	0.388*							
13. MNE age	1.57	0.46	0.04	−0.168*	−0.502*	−0.01	0.221*	0.357*	0.315*	0.409*	0.264*	0.278*	0.433*	0.356*						
14. Country-specific cost of scient. labor	4.73	0.16	0.06	0.04	0.291*	0.323*	−0.670*	−0.345*	−0.148*	−0.228*	−0.03	−0.10	−0.335*	−0.201*	−0.10					
15. Market demand	13.05	0.44	0.04	−0.178*	−0.06	0.775*	−0.125*	0.433*	0.387*	0.237*	0.205*	0.122*	0.132*	0.04	0.175*	0.169*				
16. Country-specific education	5.58	0.15	0.04	0.04	0.400*	0.423*	−0.777*	−0.354*	−0.246*	−0.197*	−0.06	−0.151*	−0.369*	−0.120*	−0.178*	0.717*	0.322*			
17. Emerging and developed counties	0.13	0.17	−0.125*	−0.04	−0.417*	−0.07	0.753*	0.525*	0.381*	0.291*	0.193*	0.277*	0.441*	0.269*	0.222*	−0.600*	0.133*	−0.504*		
18. Country-specific economic growth	0.45	0.13	0.00	−0.103*	−0.283*	−0.147*	0.752*	0.555*	0.424*	0.277*	0.200*	0.207*	0.356*	0.316*	0.204*	−0.556*	0.08	−0.444*	0.719*	
19. Country-specific gov. effectiveness	1.95	0.03	0.132*	0.07	0.313*	−0.06	−0.597*	−0.462*	−0.366*	−0.273*	−0.186*	−0.234*	−0.444*	−0.123*	−0.163*	0.531*	−0.237*	0.455*	−0.766*	−0.447*

* $p < 0.05$.

Table 3
Regression results (dependent variable: MNE productivity performance).

	Model 1		Model 2		Model 3		Model 4		Model 5 (OLS)		Model 6 (Lev-Pet)		Model 7 (2SLS)	
	Coef.	p-Value	Coef.	p-Value	Coef.	p-Value	Coef.	p-Value	Coef.	p-Value	Coef.	p-Value	Coef.	p-Value
H1: Globally dispersed knowledge × Ineffectiveness of IPR protection			1.161	0.000	0.998	0.003	1.189	0.000	0.423	0.001	0.143	0.665	1.304	0.000
H2: R&D × Ineffectiveness of IPR protection					0.879	0.000	0.843	0.000	0.333	0.000	1.261	0.000	0.712	0.000
H3: IPR heterogeneity							0.026	0.000	0.012	0.000	0.032	0.003	0.026	0.002
Geographic dispersion of R&D × Ineffectiveness of IPR protection							−0.107	0.001	−0.056	0.000	0.019	0.687	−0.079	0.003
R&D	0.286	0.000	0.264	0.000	0.374	0.000	0.392	0.000	0.158	0.000	0.529	0.000	0.564	0.000
Globally dispersed knowledge	0.163	0.003	0.236	0.000	0.192	0.001	0.276	0.000	0.108	0.001	0.057	0.391	0.608	0.000
Ineffectiveness of IPR protection	−0.175	0.210	−0.157	0.262	−0.322	0.045	−0.493	0.004	−0.201	0.007	−0.366	0.102	0.515	0.135
Geographic dispersion of R&D	−0.015	0.007	−0.019	0.001	−0.012	0.055	0.015	0.136	0.006	0.179	0.001	0.936	−0.026	0.005
Internationalization of R&D	0.311	0.008	0.357	0.002	0.084	0.588	0.040	0.797	0.022	0.777	−0.145	0.363	−0.145	0.323
MNE profitability	0.035	0.000	0.037	0.000	0.031	0.000	0.031	0.000	0.010	0.000	0.050	0.000	0.052	0.000
Internationalization of sales	−0.001	0.973	−0.038	0.309	0.018	0.638	0.012	0.755	0.017	0.299	0.124	0.003	0.153	0.000
Internationalization of assets	0.013	0.604	0.020	0.400	0.054	0.017	0.087	0.000	0.015	0.150	−0.018	0.443	−0.019	0.431
MNE size	0.205	0.000	0.132	0.001	0.192	0.000	0.189	0.000	0.008	0.694	0.723	0.000	0.226	0.000
Product diversification	0.081	0.003	0.067	0.016	0.034	0.265	0.034	0.312	0.022	0.144	0.414	0.000	0.048	0.166
MNE age	−0.116	0.017	−0.085	0.077	−0.197	0.001	−0.140	0.007	−0.041	0.089	0.085	0.181	−0.240	0.000
Country-specific cost of scient. labor	0.360	0.003	0.157	0.194	0.397	0.007	0.365	0.016	0.182	0.003	0.102	0.586	0.355	0.056
Market demand	−0.085	0.104	−0.126	0.014	−0.096	0.073	−0.163	0.011	−0.082	0.008	0.177	0.014	−0.054	0.442
Country-specific education	−0.439	0.013	−0.454	0.010	−0.561	0.002	−0.523	0.004	−0.216	0.010	−0.086	0.681	−0.843	0.000
Emerging and developed counties	−0.124	0.155	−0.115	0.197	0.008	0.799	−0.022	0.747	−0.009	0.796	−0.677	0.000	−0.314	0.065
Country-specific economic growth	0.502	0.002	0.432	0.005	0.597	0.000	0.422	0.010	0.206	0.004	1.028	0.000	0.567	0.000
Country-specific gov. effectiveness	1.061	0.052	1.568	0.002	0.684	0.139	0.385	0.489	0.161	0.482	−0.363	0.541	0.499	0.425
Industry and time dummies	Included		Included		Included		Included		Included		Included		Included	
Observations	370		370		370		370		370		370		370	

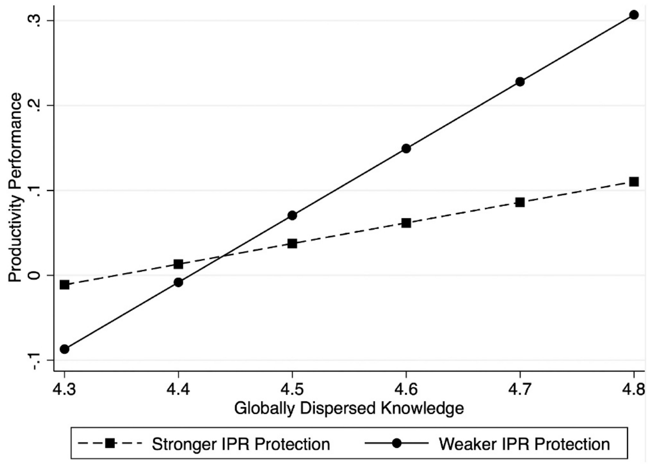

Fig. 1. Productivity effects of globally dispersed knowledge (predicted margins).

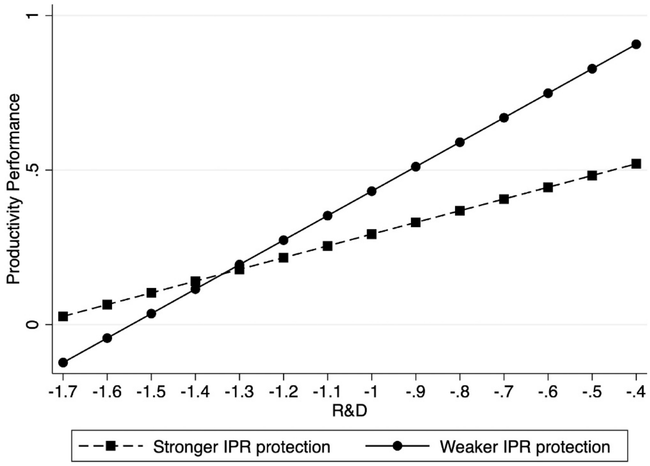

Fig. 2. Productivity effects of R&D (predicted margins).

relationships.

Third, we examined the sensitivity of the results to different time lags. The findings were less sensitive to different lags for globally dispersed knowledge, but a three-year lag maximized the productivity effects. Finally, we used an alternative market demand measure to account for international differences in purchasing power parity, alternative R&D measures using 15–25 % depreciation rates and alternative controls for MNE profitability (return of assets, operating profit margin and operating income). The results remained similar.

5.3. Endogeneity

Endogeneity may arise when highly productive MNEs differ in their propensity to locate R&D in weak IPR regimes. In such cases, productivity performance may affect the measure of IPR ineffectiveness, rather than the opposite. Similarly, productive MNEs may exhibit a higher (or lower) propensity to locate in heterogeneous IPR regimes, which implies that productivity may determine the measure of IPR heterogeneity (while we hypothesize the opposite). To deal with this potential concern, we re-estimated the models using two-stage least squares (2SLS), which is a widely adopted approach in the IB (Wang et al., 2012b) and innovation literatures (Kafouros et al., 2021). The first stage of this approach uses instruments to predict values for the potentially endogenous regressors (*IPR ineffectiveness*, *IPR heterogeneity* and *R&D* in our analysis). The predicted values enter the second stage (instead of the initial predictor variables) to test the hypothesized effects (Wooldridge, 2010).

We followed standard practice (Gujarati and Porter, 2009; Kafouros et al., 2021; Wang et al., 2012b; Wooldridge, 2010) and used the lagged variables of MNE's R&D, IPR ineffectiveness and IPR heterogeneity as instruments. The justification for using such instruments is twofold and has extensively been discussed in the literature (Wang et al., 2012b; Wooldridge, 2010). First, IPR-related decisions, location choices and other events associated with these variables that occurred in the past are not correlated with the error term in the present (Gujarati and Porter, 2009; Wooldridge, 2010). Second, although the strength of IPR protection in a country may affect the R&D location choices of an MNE, it is nevertheless exogenously determined by certain institutional forces in each country (that a single MNE cannot significantly affect).

Model 7 in Table 3 reports the results of the 2SLS approach. These results are similar to those obtained from the main estimator in Model 4, confirming the hypotheses. We have also followed prior studies and examined the endogeneity of the key variables by conducting a Hausman test to compare the main estimator (Model 4) with the 2SLS estimator. The results of the test indicate that the null hypothesis that the variables are exogenous cannot be rejected, suggesting that differences in the initial and 2SLS estimates are not systematic (Wang et al., 2012b; Wooldridge, 2010). This indicates that the key variables (*IPR ineffectiveness*, *IPR heterogeneity* and *R&D*) should jointly be treated as exogenous and that the initial estimator (Model 4) should be preferred to 2SLS. Overall, this additional analysis shows that endogeneity does not pose a significant threat to our analysis and confirms that the results remain the same when the 2SLS approach is used.

6. Discussion and conclusion

6.1. Theoretical contributions and practical implications

R&D internationalization can profoundly affect value creation and capture and, thereby, MNEs' productivity performance. It is therefore seen as a strategic imperative for MNEs. Although the benefits and challenges associated with weak and strong IPR regimes are well understood (Kafouros et al., 2021; Papanastassiou et al., 2020), it remains unclear whether MNEs that locate some of their R&D units in weak IPR regimes improve their performance more (less) than MNEs that concentrate their R&D in strong IPR protection countries. To address this limitation in our understanding, we examine how MNEs can internationalize their R&D in a way that enhances the efficacy of their own R&D and the benefits of accessing globally dispersed knowledge, while reducing the negative effects of weak IPR protection on their productivity performance. Hence, the study advances research on the role of R&D internationalization in different IPR regimes (Bruno et al., 2021; Ray and Ray, 2021) and the performance consequences of such strategic decisions (Deng et al., 2018; Driffield et al., 2016; Idris et al., 2022; Tojeiro-Rivero, 2022; Un and Rodríguez, 2018; Xu et al., 2021).

The first contribution of the study lies in explaining why R&D internationalization does not affect the productivity performance of all MNEs equally. We develop the overarching premise that variations in productivity performance are driven by the way in which MNEs distribute their R&D units across weak and strong IPR protection countries. This explanation shifts attention (Tojeiro-Rivero, 2022; Xu et al., 2021) from the *degree* of R&D internationalization to *how* MNEs should internationalize their R&D and the IPR context of such location choices. Our framework advances this explanation by identifying and testing three inter-related mechanisms that collectively determine MNEs' productivity: (1) the efficacy of MNEs' R&D, (2) the advantages of accessing globally dispersed knowledge, and (3) MNEs' ability to exploit cross-country differences in IPR protection.

Integrating research on locational advantages (Yang and Driffield, 2022) and theory from the value capture and evolutionary perspectives, the study revisits the common assumption that weak IPR protection is disadvantageous for MNEs. While it does not necessarily suggest that weaker IPR protection improves productivity directly, it shows that despite certain challenges, conducting R&D in weaker IPR regimes enhances not only MNEs' ability to exploit knowledge from other countries but also the efficacy of their own R&D. We argue that weaker IPR regimes facilitate the utilization, sequential accumulation and re-combination of external knowledge and technologies in each ecosystem and, in turn, have a profound effect on MNEs' productivity performance. Our framework extends the productivity literature (e.g., Driffield et al., 2016) and evolutionary perspectives that focused on a single location (e.g., Dosi et al., 2006) by explaining how innovating in *multiple* contexts simultaneously can provide a diverse set of advantages, even when it makes technology protection more challenging.

A second contribution of the study concerns the role of *IPR heterogeneity*. We provide evidence and explain why MNEs enhance their productivity when they locate R&D in *both* strong and weak IPR protection countries. In contrast to the prevalent view that weak IPR protection encourages imitation and decreases the returns to R&D, we show that locating R&D units in both strong and weak IPR protection countries enhances value creation and capture in MNEs. While prior studies largely focus on how IPR regimes affect technology protection, we argue that IPR regimes also determine what types of innovation and technologies firms can access, utilize and learn about (Dosi and Nelson, 1994; Nelson, 2009). We accordingly argue that IPR heterogeneity enhances MNEs' productivity by allowing them to exploit advantages that are specific to certain IPR regimes (i.e., they benefit from IPR-specific advantages that cannot be exploited when MNEs operate in highly homogeneous IPR regimes).

Taken together, our analysis contributes to recent work that emphasizes that various performance outcomes can be explained by 'how' MNEs organize the development of innovation across geographic boundaries (Kafouros et al., 2022). It also challenges the view that MNEs should always conduct inventive activities in strong IPR protection countries. While strong IPR protection might be crucial for firms that innovate in a single country and must rely on the legal system to a greater extent, we show that it is advantageous for multi-location MNEs that distribute R&D across both strong and weak IPR regimes (Zhao, 2006).

Our analysis also provides guidance on how managers could identify locations for R&D and how they should geographically configure MNEs' global R&D portfolios. Multi-location MNEs should not consider weak IPR protection countries as disadvantageous contexts, but equally our analysis does not imply that MNEs should locate all their R&D units in weak IPR regimes. As these contexts provide significant advantages, locating some R&D units in weak IPR protection countries increases the returns to the MNE's own R&D and the utilization of external knowledge. Furthermore, what matters is not only the effectiveness of IPR protection in a particular market, but also how interdependencies in the MNE's R&D portfolio enable the organization to access different IPR-specific advantages. This requires evaluation of how IPR protection in each country differs from that in other R&D locations and careful consideration of which mechanism is more effective for developing technology within the MNE. In this respect, innovating in a mix of countries with both strong and weak IPR protection can be a fruitful way to enhance the productivity performance of the MNE.

6.2. Limitations and directions for future research

First, R&D units may differ in terms of type (e.g., adaptation, listening posts, patent generation units), products (e.g., vaccines, drugs, consumer health) and the nature of R&D (e.g., exploratory or exploitative; Mavroudi et al., 2020). Such differences may influence the locational advantages that each R&D unit can access, the mechanisms of value creation and capture, and how technology can be protected. Although many MNEs do not report detailed information about each of their R&D units (and many R&D units are assigned multiple roles), detailed information on each R&D unit will enable future research to explain value creation and capture mechanisms, how IPR regimes affect each type of R&D unit, and whether different types of R&D units are equally equipped to exploit such advantages (Kafouros et al., 2022).

Second, while our study focused on the benefits of sourcing knowledge informally through spillovers, MNE subsidiaries can also source knowledge through contractual agreements, such as technology licencing and acquisitions. Future research can advance our knowledge of the consequences of R&D location choices by examining how IPR protection influences such formal types of knowledge sourcing. For example, strong knowledge spillovers in weak IPR regimes may reduce the firm's need to source knowledge through formal means. Third, the effects of location-specific advantages may differ significantly between developed-country MNEs and MNEs from emerging economies that face different constraints and focus on different types of innovations (Kumar et al., 2020). Examining the hypothesized relationships for emerging economy MNEs will be another worthwhile way to extend the current study. Finally, future research can explore such effects on financial performance (e.g., growth and profitability) and innovation performance (e.g., patent output and radical/incremental innovations). Although the dynamics underlying financial and innovation performance differ considerably from productivity-specific dynamics, such comparisons can yield valuable theoretical insights into how R&D location choices affect the overall performance of the MNE.

Data availability

The authors do not have permission to share data.

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