Linking together Penrose's Two Streams of Intellectual Contributions: The Use and Protection of Knowledge Resources within and across Firms and Countries

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ABSTRACT

Edith Penrose's theory of the growth of the firm is widely recognized in strategic management. By contrast, her contribution to research on the international patenting system is much less well known among management scholars. In this paper, we link together Penrose's two streams of intellectual contributions, by focusing sharply on the use and protection of knowledge resources—within and across firms—domestically and internationally. Applying a transaction cost economics lens, we propose that an effective (international) patent system makes it possible to separate the use from the ownership of knowledge resources, thus facilitating a broader use of such resources for achieving firm growth, within and across organizational and geographic boundaries.

Keywords: Firm growth, knowledge resource, use and ownership, patent, intellectual property right (IPR), appropriability hazard, transaction cost theory, resource-based theory.

INTRODUCTION

In1959, Edith Penrose published the second book in her life, *The Theory of the Growth of the Firm*, proposing a new theory of firm growth characterized by disequilibrium growth pattern under uncertainty and challenging the fundamental assumptions of the dominant neo-classical economic paradigm (Foss, 1999; Rugman & Verbeke, 2002, 2004). In this book, she proposed a theoretical framework that views the firm as a bundle of productive and managerial resources, and grounds the growth of the firm on its use of such resources (Kor & Mahoney, 2004; Penrose, 1959; Pitelis, 2004). Despite debates regarding the connection between this book and the resource, capability, and knowledge based theories of the firm (e.g., Barney, 2000; Kor & Mahoney, 2000; Rugman & Verbeke, 2002), researchers in the management field commonly refer to this book as the foundation of what has later become known as the resource-based view (RBV) of the firm (e.g., Teece, 1980; Teece, Pisano, & Shuen, 1997; Wernerfelt, 1984). Hence, Penrose's 1959 book is widely perceived as one of the cornerstones for the field of management and related fields such as international business and entrepreneurship.

By contrast, her contributions to the patent system, as shown by her first published book *The Economics of the International Patent System* (Penrose, 1951) and other works (Penrose, 1973), are much less well known among management scholars. In this line of studies, she approached the international patent system from social welfare and economic efficiency perspectives, and criticized the inefficiency of such a system for developing countries, along with potential solutions to the distortion created by the system. Her work informed economists and management scholars of the importance of examining the effectiveness and efficiency of the intellectual property right (IPR) system, especially in developing countries (e.g., Helleiner, 1975; Mansfield, 1995). While each stream of her research is very influential, it would appear that the

two streams developed independently and hence are subject to their own limitations. In this paper, we explore the intellectual foundation of Penrose's research and argue that her two streams can be linked together by focusing sharply on the role of knowledge resources, and by analyzing the scope of the *services* of such resources—whether within or outside the firm, and whether domestically or internationally—using a transaction cost economics lens (Williamson, 1975, 1985).

We focus on knowledge resource, an important type of resource for the growth of the firm downplayed in Penrose's 1959 book (Kogut & Zander, 1992; Grant, 1996). Compared to other resources, knowledge resource is characterized by several unique characteristics: knowledge is a type of public goods that is both non-rivalrous and non-excludable (Romer, 1990), and simultaneously is also a type of private goods that requires firms to bear costs during the development process (Maskus, 2000; Nelson, 1989). The non-rivalrous nature of knowledge resource makes possible the use of the resource across organizational and geographic boundaries. However, the non-excludable nature and the private goods characteristic of knowledge present challenges to the separation of its use from ownership. This separation gives rise to the classic transaction cost problem in the form of knowledge leakage and appropriability hazards (Williamson, 1985; Teece, 1986a). We propose that an effective IPR system can establish an isolating mechanism to help secure firms' ownership of knowledge resources and strengthen the appropriability of resources by firms, enabling the separation of the *use* from the ownership of these resources (Teece, 1986a; Gans & Stern, 2003). Correspondingly, an effective IPR system enables a market for the exchange of knowledge resources between organizations and across geographical boundaries. Furthermore, knowledge can be categorized into two types (tacit knowledge and explicit knowledge) based on its codifiability and transferability (e.g., Polanyi,

1966; Zander & Kogut, 1995). Different types of knowledge are subject to different levels of IPR protection and hence have different implications for knowledge transfer within the organization and knowledge exchange between organizations.

Our theoretical framework has several messages for scholars of our time regarding Penrose's *The Theory of the Growth of the Firm*. First, we submit that, to better appreciate Penrose's contribution to the management field in present days, the role of knowledge resources should be highlighted, given that knowledge and innovation are the key driver of business and economic growth (Freeman, 1974; Teece, 2010; Tushman, 1997). Second, separation of the use from the ownership of knowledge resources is a necessary condition for maximizing the opportunity for the growth of the firm and fully realizing the value of these resources. However, this separation and the non-excludable nature of knowledge resources give rise to transaction cost problems in the form of knowledge leakage and appropriability hazard. IPR system provides firms with a legal means to address these problems both *ex ante* and *ex post*. Hence, knowledge resource—its uses and its protection through IPR—is the nexus of Penrose's two streams of research on firm growth and patenting systems. Specifically, we use transaction cost theory to link together her two streams of research by focusing on the opportunities and challenges brought about by knowledge resources, when thinking about the growth of the firm within and across organizational and geographic boundaries.

BACKGROUND LITERATURE

In her seminal book *The Theory of the Growth of the Firm*, Penrose (1959) proposed a value-creation framework and argued that the key input to a firm's production process is the services/uses (a function of the use of the productive resources) rendered by the resources,

instead of resources themselves. Her framework focused on the role of managerial capabilities and experiences in determining the uses rendered by the firm's resources, which contribute to the growth of the firm. Accordingly, the limitation of a firm's growth hinges on managerial resources' capability to discover and adapt to new opportunities by deploying unused resources in an environment that is characterized by disequilibrium and uncertainty. This perspective implies the importance of learning by managerial resources (Foss, 1999) and treats knowledge as part of managers' capability. Furthermore, two types of firm growth are central to Penrose's (1959) work: 1) diversification, which is an increase in the number of "basic areas" (p. 109) a firm operates based on the opportunity and the corresponding unused services of resources; and 2) acquisitions and mergers, where the firm identifies opportunities to purchase and combine with another firm to deploy unused services of resources.

Despite the enormous insights offered, Penrose's (1959) book has been suggested to have several limitations, given its focus and time. First, the use rendered by knowledge resources, an increasingly important engine of firm growth in the economy, was not a core concern despite the insinuation of the existence of such kind of resources (Foss, 1999). In her book, she suggested that the interaction between managerial resources and other production resources facilitates within-firm knowledge creation that was manifested as productivity improvements (Penrose & Pitelis, 1999). However, she did not address other varieties of knowledge resources such as technologies or innovations that are often in the form of patents, copyrights, or trade secrets, and thus did not discuss how these knowledge resources contribute to the growth of the firm. Second, the framework focused on the growth within the firm; even in the case of M&As, the focus was on the ownership and use of resources *within* the merged entity. The framework did not incorporate external expansions involving "lending" the use of the firm's resources to partners,

"borrowing" the use of resources from partners (e.g., licensing), or "pooling" resources together between partners (e.g., alliances, open innovation platforms)—what has become known as collaborations and market for technologies today (Gans & Stern, 2003; Barney & Tong, 2004; Capron & Mitchell, 2012). In fact, this neglect of collaboration and market for technology was later recognized by Penrose herself in the foreword of the 1995 edition of *The Theory of the Growth of the Firm*, making this an interesting topic for scholars to explore.

Furthermore, international growth is overlooked as a means firms grow in this book (Penrose, 1959). However, she did recognize international expansion in her other studies. In her other works (Penrose, 1956, 1959b), she discussed how multinational enterprises (MNEs) make excess profits from their international expansion in poorer countries. She focused on social welfare and argued that MNEs investing in developing countries could damage local economies because of their excessive rent seeking behavior. Finally, Penrose (1959) proposed a theory of value creation and focused on describing the process of the growth of the firm and the social efficiency originating from such growth (Rugman & Verbeke, 2002, 2004). As a result, the original framework did not provide guidance regarding value appropriation, an essential concern for strategy scholars (e.g., Brandenburger & Stuart, 1996).

In the other stream of research on international patent systems (Penrose, 1951, 1973), Penrose analyzed and criticized the inefficiencies created by these systems from a social welfare perspective. She argued that MNEs acquire patents in host countries to fend off local firms and extract monopoly rents, and therefore generate only limited benefits to local welfare and technology development. The role of international patent systems in motivating MNEs' foreign direct investment (e.g., Glass & Saggi, 2002; Khoury & Peng, 2011) in developing countries and creating dynamic efficiencies in global resource recombination was not a focus in her work.

Because of its unique focus on social welfare and development economics, which possibly explains why it receives less attention in the management field, this stream of work did not feature any salient analysis of MNEs using the theory of the growth of the firm in her 1959 book. Generally, IPR systems in her perspective did not provide effective incentives for firms' knowledge creation and utilization, echoing other economists' criticism of IPRs (e.g., Dosi, 1988). This approach is partially the result of the maleficent assumptions regarding the value appropriation (e.g., monopoly rents) motive of firms holding patents.

Despite the apparently independent development of the two streams of studies, we believe that a deep connection exists between them and that the nexus lies in the consideration of separating the use from the ownership of knowledge resources. A key enabling condition, then, is patent systems, or intellectual property right regimes more generally. By facilitating the separation of the use from the ownership of knowledge resources, (international) patent systems play a critical role in driving firm growth, in terms of both the organizational (within-organization or inter-organizational) scope as well as the geographic (domestic or international) scope of expansion.

FIRM GROWTH WITHIN AND ACROSS ORGANIZATIONAL BOUNDARIES

To articulate our point, we develop a framework (see Figure 1) to link together Penrose's two streams of works by focusing on the "use" of knowledge resources and the role of IPR systems. Drawing from transaction cost economics, this framework illustrates how IPR systems may affect firms' use of knowledge resources and accordingly, shape their scope of expansion along organizational and geographic dimensions.

----------Insert Figure 1 about Here----------

IPR and Firms' Organic Growth through Use of Knowledge Resources

Knowledge resources and the use of this type of resources are a critical driver of the growth of a firm (Audretsch, 1995; Coad & Rao, 2008). Just like other types of resources (Penrose, 1959), firms can deploy and combine their existing and underutilized knowledge resources to pursue and adapt to new opportunities (Eisenhardt & Martin, 2000; Teece et al., 1997). For instance, firms in the optoelectronics industry are powered by the combination of the existing electronic, crystal, and optic knowledge resources (Hargadon, 1998). Moreover, according to the knowledge recombination view, knowledge resources are themselves sources of new opportunities, since firms can explore new recombinations of their existing knowledge components (Fleming, 2001; Schumpeter, 1939). Both Rolls Royce and Porsche are good examples of recombining and redeploying their existing car engine technologies for new opportunities in jet engines. PFM 3200 was a six-cylinder air-cooled aircraft engine developed by Porsche utilizing technologies from the engine in a Porsche 911 Carrera 3.2. Similarly, Rolls Royce's Eagle jet engine developed during World War I was the result of knowledge recombinations based on the existing 7.4 liter Silver Ghost engine. Hence, knowledge resources can be seen as "always" underutilized, to some degree, given their potential to be recombined with other components to generate new knowledge. Despite their potential contribution to firms' growth, knowledge resources are challenging to manage and develop.

As a type of public goods, knowledge resource is both non-rivalrous and non-excludable (Romer, 1990). Different firms can use a given knowledge in different locations at the same time, without knowing each other using the resource. Knowledge resource is also a type of private goods that incurs private cost bearing during the development process (Maskus, 2012). The "dual" nature of knowledge resources presents challenges to firms that develop them. Firms

are threatened by potential imitation given the non-excludable nature of knowledge and thus, have limited incentive to invest in its development given the weakened value appropriation potential (e.g., Hall & Harhoff, 2012; Mansfield, Rapoport, Romeo, Wagner, & Beardsley, 1977). Without some types of external interference, knowledge resources may be in short supply, since developers may not be able to recoup the investment cost.

IPR systems such as patent laws provide an isolating mechanism to help secure firms' ownership of knowledge resources and strengthen the appropriability of the resources (Teece, 1986a). An effective IPR system can fend off imitators and help firms protect their knowledge resources from imitation, so that they can better utilize knowledge resources to achieve sustainable growth. This primary relationship between firm growth and IPRs is described in the top left quadrant I in Figure 1.

IPR and Firm Growth through Inter-Organizational Exchange of Knowledge Resources

Just like other production resources (Penrose, 1959), knowledge resources that contribute to the growth of a firm can exist not only within the firm but also outside the firm boundaries with *other* firms. Similarly, the non-rivalrous nature of knowledge resources (Romer, 1990) and underutilized services of knowledge resources within a focal firm can also be the foundation for the growth of *other* firms.

Firms can source external knowledge resources through acquisitions and mergers. Acquisitions provide an important way firms source external knowledge (Ahuja & Katila, 2001; Younge, Tong, & Fleming, 2015). Acquisition of another firm can be seen as absorption and integration of the acquired firm's knowledge resources to the knowledge stock of the acquiring firm (Zhang & Tong, 2020). The acquisition, in turn, extends the acquiring firm's existing knowledge base and improves its innovation performance (Haspeslagh & Jemison, 1991). A

recent example would be a series of acquisitions made by Apple to support the development of Face ID, a facial recognition system pioneered on iPhone X in 2017. Acquired companies such as Perceptio and PrimeSense provide Apple with the necessary knowledge resources including technologies such as structured-light 3D scanners and machine learning powered image recognition. Similar knowledge sourcing through acquisitions also appeared in other technologies developed and powered by Apple (for example, Siri). Generally, the acquired firm's knowledge resources are absorbed and internalized by the acquiring firms, granting both the ownership and the use of these knowledge resources to the acquiring firm. Under this situation where external knowledge resources are acquired through acquisitions or mergers, IPR systems have a similar function as that described in the last section, establishing an isolating mechanism and fending off imitation.

In addition to acquisitions and mergers, firms can also source external knowledge resources by "borrowing" the use of knowledge resources from other firms, or "pooling" its own knowledge resources with the resources of other firms in a separate organization or an open innovation platform (Dyer & Nobeoka, 2000; Grant & Baden-Fuller, 2004; Zhang, Li, & Tong, 2020). Furthermore, a firm can also expand through "lending" its own knowledge resources to other firms. In the parlance of strategic management, the firm grows through inter-organizational relationships such as alliance networks (Inkpen & Tsang, 2005; Mowery, Oxley, & Silverman, 1996), market for technologies (Arora & Gambardella, 2010), and open innovation platforms (Baldwin & Von Hippel, 2011). These channels of growth are receiving increasing attention nowadays, as firms often become frustrated by the tedious and lengthy M&A negotiation and integration process, as well as any antitrust implication of acquisitions of rival companies. For example, in 2016, several heavyweights and rivals in the digital economy, including Microsoft,

Google, Amazon, IBM, and Apple, jointly created an organization called Partnership on AI to Benefit People and Society. This consortium focuses on establishing the standards for AI systems and advancing the technology. As a form of inter-organizational collaboration, the Partnership on AI enables exchange of knowledge resources among firms, without going through the tedious (or simply impossible) acquisitions.

Firm growth that builds on lending, borrowing, and pooling of knowledge resources is underpinned by the ability to separate the use from the ownership of these resources. This separation, however, gives rise to classic transaction cost problems (Williamson 1975, 1985) in the form of knowledge leakage and appropriability hazards (Teece, 1982, 1986a). As discussed before, knowledge is non-excludable, which means that partners may imitate and reverse engineer knowledge resources during or after the exchange process (Kale, Singh, & Perlmutter, 2000). For instance, in alliances, partners often engage in "learning races" to learn critical knowledge from each other (Prahalad & Hamel, 1990; Khanna, Gulati, & Nohria, 1998). If a firm is not able to exclude its partners from using the learned knowledge outside the scope of the alliance, then it will be hard for the firm to appropriate value from such knowledge through other means (e.g., licensing or trade) (Arrow, 1962).

An effective IPR system is a potential solution to these transaction cost problems that result from the failure of excluding unauthorized uses of knowledge resources (Teece, 1986a; Romer, 1990). Strong IPR protection prevents illicit uses of knowledge resources by other firms by raising the cost of imitation or misappropriation with corresponding punishment and enforcement (Mansfield, Schwartz & Wagner, 1981). Therefore, strong IPR systems facilitate exchanges of knowledge resources, which in turn can contribute to the firm's growth (Arora & Gambardella, 2010). The set of ideas is captured in the top right quadrant II in Figure 1.

Types of Knowledge and Firm Growth

Related to the IPR system, another factor that affects the exchange of knowledge resources and consequently, firm growth, is the tacitness, or explicitness, of knowledge. Below we discuss how IPR systems and the tacitness of knowledge may jointly influence firms' use of knowledge and hence shape their scope of expansion within and across organizations.

Knowledge can be broadly categorized into two types based on its codifiability and transferability (Nonaka, 1994; Polanyi, 1966). Tacit knowledge cannot be codified and therefore is difficult to transfer, while explicit knowledge is codified and can be understood by others given the corresponding decipher tools (Grant, 1996; Kogut & Zander, 1992; Nonaka & Takeuchi, 1995; Polanyi, 1966). In an organization, tacit knowledge is often embodied in the form of "knowing how" and can only be revealed through its application. Explicit knowledge, on the other hand, is "knowing about facts and theories", and hence is revealed through communications as codified information (Grant, 1996). The tacitness, or explicitness, of knowledge resources gives rise to a "paradox of replication" (Kogut & Zander, 1992). On the one hand, highly codifiable and transferrable knowledge resources can be replicated and diffused at a low cost, which enables knowledge to be shared among individuals and departments within an organization. This kind of replication and diffusion, hence, provides the foundation for the growth of the firm, as it enables firms to deploy and recombine knowledge resources to pursue new opportunities. On the other hand, the low cost of replication also gives other firms easier access to these resources and encourages imitation. Imitation, in turn, prevents the owners of knowledge resources from sustaining their advantages. Compared to tacit knowledge, explicit knowledge resources are more codifiable as well as transferrable, and hence, can be replicated

and redeployed effortlessly to fuel growth. However, explicit knowledge resources are easier and more likely to be imitated.

Different types of knowledge resources thus entail different appropriability hazards (Kogut & Zander, 1992; Grant, 1996) and different levels of transaction costs (Teece, 1986a, 1986b). Specifically, explicit knowledge is subject to higher transaction costs than tacit knowledge. As discussed earlier, IPR regimes provide an isolating mechanism and enable exchanges of knowledge resources between organizations, by reducing potential transaction costs. However, IPR regimes are less effective when it comes to the protection of tacit knowledge, which is not codified and thus is hard to be specified and evaluated by formal IPRs (Gans, Hsu, & Stern, 2008; Liebeskind, 1996). Accordingly, the influence of the IPR regime on a firm's growth will depend on the type of knowledge resources owned or needed by that firm. Firms with more tacit knowledge resources, therefore, may not be able to rely on the IPR regime that much for achieving growth. By contrast, firms with more explicit knowledge have a greater need to resort to the IPR regime to prevent imitation by other firms.

The current discussion is still centered around the domestic expansion of firms. Within the same country, firms face the same institutional environment and are constrained as well as protected by the same set of IPR regulations, which provide a level playing field for the exchanges of knowledge resources. In a multinational context, IPR systems differ across countries given their unique origins and development trajectories (Peng, Ahlstrom, Carraher, & Shi, 2017; Brander, Cui, & Vertinsky, 2017). Differences in IPR systems introduce various opportunities and transaction cost issues regarding exchanges of knowledge resources, which determine the entry modes firms employ to seek international expansion.

FIRM GROWTH WITHIN AND ACROSS GEOGRAPHIC BOUNDARIES

International IPR and Firms' Organic International Expansion

International expansion is an important source and direction for firm growth (Caves, 1996; Contractor, Kundu, & Hsu, 2003; Sapienza, Autio, George, & Zahra, 2006; Tan & Mahoney, 2005). International expansion not only allows a firm to access bigger markets and gain economies of scale (e.g., Kogut, 1985; Oviatt & McDougall, 1997), but also provides opportunities to gain valuable resources from abroad (e.g., Almeida, 1996; Chung & Yeaple, 2008). However, firms seeking international growth often encounter challenges of knowledge leakage (Alcacer & Chung, 2007). Ample evidence indicates that inadvertent knowledge spillovers and rivals' purposeful imitation effort can contaminate MNEs' cross-border operation (Maskus, 2000; Driffield, Love, & Menghinello, 2010).

For MNEs, the home country IPR system cannot be easily extended overseas to protect their knowledge resources in the international market, since countries have their own IPR institutions that may or may not offer the same level or type of protection (Allred & Park, 2007; Xu & Shenkar, 2002). Furthermore, a universal international IPR standard does not exist, in spite of efforts by the World Trade Organizations (WTO) and the United Nations (UN) through the establishment of the World Intellectual Property Organization (WIPO) and the passage of The Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS) (Helfer, 2004; Peng et al., 2017). As a result, MNEs should expect a different and sometimes unfavorable IPR system in the host country. In 2013, India's Supreme Court denied a patent application for Glivec, an important treatment for leukemia developed by Novartis, in the name of social welfare and humanitarian causes, ignoring the fact that Glivec had already been patented in more than 40

countries. Hence, in India, Glivec was open to imitation and copycats, and might not generate the expected return for Novartis as in other countries where it was patented.

Despite the convergence of IPR institutions across countries in recent years, major differences among IPR systems still exist and will likely persist (e.g., Raustiala, 2006). Furthermore, despite the expected trends toward better protection of IPR in all countries, major setbacks and reversions are likely to occur in certain industries and countries during difficult times. For instance, Brazil agreed to comply with TRIPS in 1996 without invoking clauses that favored developing countries. However, the Brazilian government reverted to a regime that supports IPR violations and protectionist policies during an economic crisis in 1999 (Guennif & Ramani, 2012). Hence, MNEs need to tackle the differences between the host country and home county IPR systems to better protect their knowledge resources. The imitation and appropriability hazard issues related to knowledge resources are particularly acute for MNEs seeking to expand into countries with weak IPR protections (Brander et al., 2017; Brouthers, 2002). Research shows that knowledge leakage through imitation or outbound human resource mobility are prevalent for MNEs expanding to developing countries due to the lack of protection or enforcement caused by weak IPR systems (e.g., Keller, 2010; Peng et al., 2017).

Despite many differences across countries, an effective, internationally coordinated IPR system can help protect MNEs' knowledge resources from misappropriation by foreign or local firms. Strong IPR protection motivates MNEs' foreign direct investment and creates dynamic efficiencies in transferring knowledge resources to where their use can be furthered and maximized, which forms the *raison d'etre* for the MNE (Buckley & Casson, 1976; Dunning, 1973; Hennart, 1982; Rugman, 1982). It is now widely accepted that a strong IPR system in the host country can attract foreign investors to invest in the country given the enhanced protection

of their knowledge resources and greater value appropriation potential (Glass & Saggi, 2002; Khoury & Peng, 2011; Branstetter, Fisman, & Foley, 2006; He, Tong, Zhang, & He, 2018). Thus, a strong IPR institution in the host country or an effective international IPR system can help firms deploy their existing knowledge resources to international markets more efficiently, fueling international growth. The idea that international patent systems can facilitate firms' international expansion is captured in the bottom left quadrant III in Figure 1.

International IPR and Firms' International Expansion through Exchange of Knowledge Resources

Similar to firms seeking growth in the domestic market through exchanges of knowledge resources across organizational boundaries, firms expanding to the international market can also resort to other entry modes to obtain external knowledge resources or lend the use of their own knowledge resources to potential partners in the host country. Firms can conduct international acquisitions to tap into new knowledge resources and obtain both the ownership and the use of these resources (e.g., Bresman, Birkinshaw, & Nobel, 1999; Tan, 2009). For instance, Google acquired HTC's design team in 2018, securing the latter's knowledge resources to facilitate its own hardware development while increasing its smartphones' impact in Asia. The discussion, again, will follow the same logic of the previous section where the relationship between international IPR systems and within-organization expansion is explained. In addition to international acquisitions, firms can also rely on inter-organizational collaborations or exchanges to expand into international markets (Inkpen, 1998; Xia et al., 2018). Successful examples of international collaborations abound in the alliance literature. For instance, Siecor was created by Siemens and Corning as a joint venture (Bleeke & Ernst, 1991). Through the collaboration, Corning acquired not only the manufacturing technology and knowledge for optical fibers but

also Siemens's distribution channels across the world. On the other hand, Siemens benefited from the joint venture and gained access to Corning's technologies (patented processes of optical fiber productions).

The central consideration for the choice of entry or exchange mode still relates to transaction cost issues in the form of knowledge leakage and appropriation hazard, created by the separation of the use from the ownership of knowledge resources (Anderson & Gatignon, 1986; Caves, 1996; Teece, 1986b). Different IPR systems in host countries lead to different levels of transaction costs: a weak IPR system makes it difficult to exclude partners from appropriating firms' knowledge resources and stems inter-organizational collaborations (Teece, 1986b). Hence, for MNEs seeking expansion to the host country with a weak IPR regime, exchange of knowledge resources may not be a viable path. International acquisition and foreign direct investment may be better options. This growth trajectory (international and inter-organizational), explained in the bottom right quadrant IV in Figure 1, combines the ideas described in quadrant II and quadrant III above.

To summarize our expositions in the four quadrants, our position about the role of (international) patent systems departs significantly from that of Penrose (1951, 1973), as we see patent systems as a critical means to address potentially rampant transaction cost problems that surround the exchange of knowledge resources and inhibit firm growth, whether within the firm or across firm boundaries, and whether inside a nation or across national boundaries. As a result, it is our view that an effective (international) patent system, by checking transaction cost problems, can spur firms' domestic and international growth, through better utilization of knowledge resources within the firm, and more efficient exchange of such resources with other firms.

LIMITATIONS OF IPRS AND BROADER IMPLICATIONS

While we recognize the effectiveness of the IPR system in protecting and enabling the use of knowledge resources within and across firm and geographical boundaries, we also reckon some of the limitations of IPRs. For instance, as discussed earlier, IPRs are less effective for the protection of tacit knowledge (Gans et al., 2008; Liebeskind, 1996). In other cases, the tedious application process (Tong, Zhang, He, & Zhang, 2018) and the prolonged conflict resolution process in most IPR systems make the use of some knowledge resources or the use of knowledge resources in some scenarios challenging for firms. As one example, beginning from the early 1990s, digital knowledge resources such as software present substantial challenges to IPR systems. Copyrights and patents, two common types of formal IPRs, may not provide practical coverage given the short shelf life, short time duration between updates, and reliance on the visual aspects/functionality/sequences of software (e.g., Boudreau, 2012; Graham & Mowery, 2006; Menell, 1989, 1994; Varian, Farrell, & Shapiro, 2004). Also, knowledge used in inter-organizational collaborations may still be misappropriated even in situations with strong IPR regimes (e.g., Khanna et al., 1998). Hence, though IPR systems can enable the separation of the use from the ownership of knowledge resources, they do not fully guard against misappropriation hazards.

Distortions generated by IPR systems on social welfare also are becoming a larger concern in recent years. This concern was first voiced by Penrose in her international patent system studies (Penrose, 1951, 1973). IPR systems are regarded as not only the source of value creation and appropriation but also the foundation for value distribution (Maskus, 2000; Merton, 1988). The design of an optimal IPR system is a highly contested topic, and given the scope of

our study, we focus on how IPRs will affect the separation of the use from the ownership of knowledge resources. In recent years, RBV scholars start to emphasize the importance of incorporating a stakeholder's perspective into the original RBV model and address the importance of value distribution based on the stakeholder's role in providing and utilizing the necessary resources to create value (Barney, 2018; Cabral, Mahoney, McGahan, & Potoski, 2019; Klein, Mahoney, McGahan, & Pitelis, 2012). Given the dual (both public and private) nature of knowledge resources, the set of stakeholders necessarily extends beyond the firm and country boundaries, as such resources are created, utilized, and regulated by inventors, firms, general public, and government. Hence, to address the question of value distribution among stakeholders and to reduce social welfare distortions related to the protection of knowledge resources, the establishment and development of IPR systems should also incorporate a stakeholder perspective (Prud'homme, Tong, & Han, 2019). Accordingly, countries need to take into account key stakeholders' interests (e.g., firms as resource owner, individuals as resource creator, governments as regulator, and customers as beneficiary), and create IPR regimes that can enable the protection of knowledge resources—and through the process, incentivize the creation, and expand the legitimate utilization, of such resources—while reducing the distortions to social welfare.

FUTURE RESEARCH

We hope that our framework, with its focus on the use and protection of knowledge resources within and across firms and countries, can expand the existing understanding of Penrose's theory of the growth of the firm, and link it with her other important stream of work on

(international) patent systems. Based on the framework, we suggest two potential areas for future Penrosian research.

We believe there is significant value in studying the moderating role of knowledge characteristics in shaping the effect of patent sytems on firm growth. We have argued that knowledge resources present a use-ownership separation challenge, given its non-rivalrous and non-excludable nature. However, heterogeneities exist among different types of knowledge resources along these two dimensions. We have already discussed the implications of one such heterogeneity, knowledge tacitness. Other knowledge characteristics, such as complexity or interdependencies, can also defy imitation (Zander & Kogut, 1995), and it would be valuable to study how such characteristics may interact with patent systems in shaping firm growth.

In addition to patents and formal IPRs, firms may also turn to organizational and other means for knowledge protection, including trade secrets, employment contracts (e.g., non-compete agreements), job design, organizational structure, reputation for toughness, strategically placing R&D facilities in different locations and countries, and so forth (e.g., Hannah, 2005; Liebeskind; 1996; Younge et al., 2015). Thus, another fruitful way to advance research is to look at the interaction between (international) patent systems and organizational strategies in affecting knowledge protection and driving the (international) growth of the firm.

DISCUSSION AND CONCLUSION

In this paper, we develop a framework to link together the two seemingly independent research streams developed by Edith Penrose, through a focused analysis of the role of knowledge resources and the transaction cost of using such resources to achieve firm growth. Patents and IPR systems, both in domestic and international contexts, play a vital role in

addressing the transaction cost issues due to the separation of the use from the ownership of knowledge resources.

The framework proposed complements the existing Penrosian perspective and has implications for scholars in the management field. To begin with, we aim to provide readers with a contemporary take of Penrose's seminal work *The Theory of the Growth of the Firm* by focusing on knowledge resource, a type of resource that is mostly neglected in her original work. Innovation is one of the more important drivers of business success and economic growth (Arrow,1962; Schumpeter, 1939). Management of knowledge resources, both the source and the result of innovation, is thus a critical challenge to firms and countries alike (Lerner & Stern, 2012). Given the specific time when the 1959 book was written, knowledge resources were not treated as a critical source of value creation and hence was not directly linked with the growth of the firm (Penrose, 1959). Hence, by complementing her original work with a critical analysis of the role of knowledge resources, we hope readers can better appreciate Penrose's contribution in current days.

In addition, we propose that the separation of the use from the ownership of knowledge resources is a necessary condition for maximizing the value of such resources and thus the growth of the firm. Knowledge is a public good as well as a private good (Maskus, 2000). The non-rivalrous nature of knowledge allows it to be shared as a public good (Romer, 1990). Theoretically, a knowledge resource can be used simultaneously by many entities and hence can only achieve maximum efficiency when multiple parties benefit from using it. Thus, the owner of knowledge resources can lend the use of these resources to many others to maximize the return so as to better compensate for the resource's development cost. Furthermore, the user of knowledge resources can also borrow, or pool its own resources with, others' knowledge

resources to fulfill its own goals without going through the lengthy development or acquisition process. As a result, the nature, and the utilization and protection of knowledge resources present many opportunities to refine the original Penrosian framework.

Perhaps the greatest conundrum facing firms in managing knowledge resources is to maximize the use of such resources for growth while containing the transaction cost due to the separation of the use from the ownership of resources. The non-rivalrous nature of knowledge resources enables the simultaneous use of such resources. However, their non-excludable nature gives rise to potential knowledge leakage and appropriability hazard (Teece, 1986a; Gans & Stern, 2003; Stiglitz, 1999); as a result, knowledge resources are difficult to be exchanged efficiently, inhibiting the growth of the firm. Means that can check transaction cost, therefore, can facilitate efficient use and exchange of knoweldge resources, fueling firm growth. It is our view that IPR systems represent one such means—arguably the most important one—to reduce transaction cost, facilitate the use of knowledge, and spur firm growth across organizational and geographic boundaries. We believe this view also helps to link together Penrose's two important streams of research: firm growth and patent system.

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Figure 1. Firm Growth across Organizational and Geographic Boundaries: The Role of Protection of Knowledge Resources via IPR

Geographic Boundary	Organizational Boundary: Within-Organization	Organizational Boundary: Inter-Organization
Domestic (within-country)	(I) • Firms expand by "deploying" their own resources and unused capacity to new business domains – this is the core idea in Penrose (1959) • IPR helps protect the firm's knowledge resources from misappropriation by other firms – the role of IPR is not a focus in Penrose (1959)	(II) • Firms expand into new business domains by "lending" the use of their resources to partners, by "borrowing" the use of resources from partners, or by "pooling" resources together between partners – expansion through collaborative means is not a focus in Penrose (1959) • IPR helps protect the firm's knowledge resources from misappropriation by other firms – the role of IPR is not a focus in Penrose (1959)
International (cross-country)	(III) • Firms expand by "deploying" their own resources and unused capacity to other countries – international expansion is not a focus in Penrose (1959) • International IPR helps protect the firm's knowledge resources from misappropriation by foreign firms – the role of international IPR is analyzed in Penrose (1951), but from the perspective of static social welfare	(IV) • Firms expand into new business domains in other countries by "lending" the use of their resources to foreign partners, by "borrowing" the use of resources from foreign partners, or by "pooling" resources together between partners cross-border – international expansion through collaborative means is not a focus in Penrose (1959) • International IPR helps protect the firm's knowledge resources from misappropriation by foreign firms – the role of international IPR is analyzed in Penrose (1951), but from the perspective of static social welfare