10.5465/AMBPP.2021.142

KNOWLEDGE SPILLOVERS IN SCHUMPETERIAN ENVIRONMENTS: ASSYMETRIES BETWEEN NEW ENTRANTS AND INCUMBENTS IN SPURRING INNOVATIONS BY OTHER FIRMS

FRANCISCO POLIDORO JR.
McCombs School of Business
The University of Texas at Austin
Austin, TX 78712

CHARLOTTE JACOBS
Temple University, Philadelphia

INTRODUCTION

Tracing back to Schumpeter (1934, 1950), the patterns of innovations that new entrants and incumbents create have been a major theme in research on technological change and evolution (Nelson & Winter, 1982; Levinthal, 1992; Malerba & Orsenigo, 1995). In line with the Schumpeterian notion of creative destruction, the literature has largely viewed new entrants as key sources of technological discontinuities, given their focus on innovations that radically depart from existing technologies, in contrast with incumbents, which favor instead incremental refinements of existing technologies (e.g., Abernathy & Utterback, 1978; Tushman & Anderson, 1986; Hill & Rothaermel, 2003). Research has also shown that radical innovations exhibit a greater potential for spawning subsequent innovations (Ahuja & Lampert, 2001; Kneeland, Schilling, & Aharonson 2020; Polidoro & Yang, 2020). But, the nonrivalrous and nonexcludable nature of knowledge precludes firms from capturing all the generative potential of their innovations (Arrow, 1962; Ahuja, Lampert, & Novelli, 2013), resulting in knowledge spillovers, that is, "external benefits from the creation of knowledge that accrue to parties other than the creator" (Agarwal, Audretsch, & Sarkar, 2010: 271). By attributing to new entrants greater proclivities to create innovations that are inherently more generative, the creative destruction framework offers the conjecture that new entrants might disproportionately contribute to knowledge spillovers. Yet, research thus far has stopped short of investigating this conjecture.

Recently however, in contrast with he notion of creative destruction, the literature has proposed creative construction in which both new entrants and incumbents draw upon novel technologies to create their innovations which generate knowledge spillover that other firms can built upon (Agarwal et al., 2007; Cozzolino & Rothaermel, 2018; Giustiziero et al., 2019). When both new entrants and incumbents are similarly engaged in creating innovations that depart from existing technologies, asymmetries in the extent to which they generate knowledge spillovers behoove us to consider factors that cannot be simply subsumed under differences in the types of innovations they create. To elucidate this issue, we conceptually explore differences between new entrants and incumbents that help explain whether the former generate more knowledge spillovers than the latter, thus spurring more subsequent innovations by other firms, even when both new entrants and incumbents create similar innovations.

In examining the differences in knowledge spillovers between new entrants and incumbents we build on the insight that a firm's generative appropriability, which refers to its ability to capture the greatest share of future innovations spawn by its own innovations, is shaped

10.5465/AMBPP.2021.142

by both its ability to preempt knowledge spillovers by effectively capturing the opportunities that its innovations spawn and its ability to deter others from building on its innovations (Ahuja et al., 2013). We argue that, relative to incumbents, new entrants are less able to both preempt knowledge spillovers and to deter other firms from drawing on the knowledge underlying their innovations. Lower ability to preempt knowledge spillovers results from the fact that, unlike incumbents, which have access to more resources, including technological resources they accumulated prior to diversifying into a nascent industry (Moeen, 2017; Roy & Cohen, 2017) and that enable them to capture the greater recombinant potential inherent in their innovations, new entrants are less able to capture that potential for themselves. Thus, new entrants leave a greater number of opportunities for other firms to seize. Lower ability to deter other firms' imitative efforts, in turn, stems from fewer resources to comit to a credible deterrence strategy (Agarwal, Ganco, & Ziedonis, 2009; Clarkson & Toh, 2010; Somaya, 2012) as well as stronger incentives to signal collaborative behavior in order to become a more connected player in the industry (Ahuja, Polidoro, & Mitchell, 2009; Polidoro & Toh, 2011). For these reasons, we hypothesize that a new entrant's innovation spurs more subsequent innovations by other firms than an innovation sharing similar technological attributes but created by an incumbent.

Our propositions are tested in the context of the terrestrial photovoltaic (PV) cell industry between 1976 and 2015. Important for this study is that in this emergent industry setting both new entrants and incumbents diversifying into this industry have been actively involved in the exploration of technological opportunities. Additionally, PV cell technologies can be distinguished based on the material used to convert sunlight into electricity. This technology feature is relevant for our study because it allows us to match innovations created by new entrants and incumbents, as we explain later.

THEORY AND HYPOTHESES

To understand the systematic differences between new entrants and incumbents in the extent to which their similar innovations generate knowledge spillovers that spur subsequent innovations by other firms, we must examine factors beyond the technological attributes of the focal innovations. Relative to incumbents, new entrants have limited resources (Stuart et al., 1999), which limits their ability to both preempt knowledge spillovers and deter other firm's efforts to draw on the knowledge underlying their innovations. Starting with new entrant's limited ability to preempt knowledge spillovers, we note that, unlike incumbents, which benefit from pre-entry resources and capabilities they have accumulated through innovation activities in other technological domains (Cattani, 2005; Helfat & Lieberman, 2002; Moeen & Agarwal, 2017), new entrants lack these technological resources. By having more resources, in particular technological resources accumulated pre-entry, incumbents enjoy enhanced generative appropriability through greater effectiveness in creating new innovations that build on their own innovations thus preempting other firms' attempts to do so (Ahuja et al., 2013: 251). By contrast, new entrants, with few resources at their disposal, are less able to capture the technological opportunities that their innovations spawn (Polidoro & Yang, 2020). Thus, even when creating similar innovations that accordingly have similar generative potential, new entrants leave a greater number of opportunities that other firms can benefit from.

Turning to lower ability to deter imitation, we note that new entrants have access to limited resources relative to incumbents and thus experience diminished abilities to engage in actions to prevent other firms from using their innovations as a springboard for creating

10.5465/AMBPP.2021.142

subsequent innovations (Ahuja et al., 2013: 251). While incumbents typically possess a broader portfolio of intellectual property that they can use in conjunction with litigiousness to deter rivals from building on the knowledge underlying their innovations (Somaya, 2012), new entrants have relatively fewer resources to detect infringement and enforce their exclusionary rights. Lacking bargaining chips in battles to assert exclusionary rights and deep pockets to sustain costly litigations (Lanjouw & Schankerman, 2001), cases of patent infringement involving new entrants' patents may be less effective in deterring imitation and can actually draw other firms' attention to their technologies (Clarkson & Toh, 2010). In addition to lower abilities to deter other firms' imitative efforts, new entrants also have weaker incentives to engage in deterrence and stronger incentives to engage in actions that may actually attract competition. As players in disadvantageous position, new entrants can benefit from exhibiting collaborative behavior in order to become a more connected player in the industry with the goal of gaining access to resources they need (e.g., Ahuja et al., 2009; Polidoro & Yang, 2020). By engaging in imitation deterrence, new entrants may push other firms toward substitutes, thereby compromising their abilities to assert the viability of their innovations (Polidoro & Toh, 2011). With these considerations, we arrive at the following baseline prediction:

> *Hypothesis 1: An innovation created by a new entrant spurs more innovations by other firms than a similar innovation created by an incumbent.*

Despite systematic differences in a cross-sectional comparison between these two groups of firms, important heterogeneities might exist across new entrants in regard to factors that shape their abilities to preempt and deter knowledge spillovers, which undergird a firm's generative appropriability (Ahuja et al., 2013).

Starting with the preemption of knowledge spillovers, we argue that the more that a new entrant has successfully appropriated the generative potential of its prior innovations, the more likely that it will be able to seize the opportunities that the focal innovation spawns (Ahuja et al., 2013: 251), thereby leaving fewer opportunities for other firms to capture. Underpinning our earlier argument is the insight that, unlike incumbents, which benefit from pre-entry resources and capabilities they have accumulated in other technological domains (Cattani, 2005; Helfat & Lieberman, 2002), new entrants have fewer technological resources that can be recombined with the knowledge underlying their innovations and thus face limitations in the scope of technological opportuities that they can capture (Polidoro & Yang, 2020). If the expectation that a new entrant has lower generative appropriability indeed encourages other firms to build on its innovation, such effect will be weaker when the new entrant has established a stronger record of capturing technological opportunities that its innovations generate. Thus, the overall tendency of new entrants to have their innovations more frequently built upon by other firms is more pronounced among new entrants with lower generative appropriability.

> *Hypothesis 2: The lower a new entrant's generative appropriability, the more that its innovation spurs more innovations by other firms than a similar innovation created by an incumbent.*

Turning to the preclusive component of generative appropriability (Ahuja et al., 2013: 251), we examine the role of litigiousness in shaping the extent to which new entrants' innovations spur more subsequent innovations by other firms than similar innovations by

10.5465/AMBPP.2021.142

incumbents. Firms in innovation-driven settings typically resort to litigiousness to deter other firms from building on the knowledge underlying their innovations (Somaya, 2012). By helping a firm establish a reputation for litigiousness (Agarwal et al., 2009), litigations against infringements of intellectual property rights not only deter the defendants but also other firms (Lemley & Shapiro,2007). Importantly, though, the extent to which a firm's patent infringement lawsuits establish a firm's reputation for litigiousness rests on the assumption that the firm will be able to "demonstrate a credible commitment to following through with the reputational strategy" (Agarwal et al., 2009). New entrants, however, have fewer resources to allocate to systematic efforts to detect infringement and to sustain costly litigations (Lanjouw and Schankerman, 2001). Additionally, as discussed earlier, new entrants face weaker incentives to commit to deterrence as doing so may interfere with efforts to gain access to resources from other organizations. With limited resources and arguably weaker incentives to commit to a sustained trajectory of litigiousness, new entrants may actually draw more attention from competitors when engaging in patent litigations. For a new entrant, incidences of patent litigations may have a stronger effect in suggesting to other firms that it has valuable technological resources, thereby attracting other firms' efforts to build on its innovation, than in signaling its strength in deterring imitation (Clarkson & Toh, 2010).

Hypothesis 3: The higher a new entrant's litigiousness, the more that its innovation spurs more innovations by other firms than a similar innovation created by an incumbent.

DATA AND METHODS

We focus empirically on the PV cell industry between 1976 and 2015 to test our propositions. To map innovations in this industry and identify the new entrants and incumbents that have been actively involved in exploring PV cell technologies, we collected patent data using Derwent Worlds Patent Index and the patent database of the U.S. Patent and Trademark Office. Data on U.S. litigation cases were obtained from Thomson Westlaw.

We identified 6,124 patents in PV cell technologies, whereof 842 were assigned to new entrants. We use Coarsened Exact Matching (Blackwell, Iacus, King, & Porro, 2009) to identify for each of these patents a counterfactual patent, it is: a patent of an incumbent firm. In our matching procedure we ensure that the pair of matched patents builds upon the same PV cell technology and is similar on a set of technological attributes (e.g., patent scope, number of backward citations, number of non-patent references, number of inventors, number of claims). The set of matched patents contains 630 patents. The final sample comprises 3,674 patent-year observations, including up to 9 years following the year of a patent's application.

In line with prior research, we rely on patent forward citations to instantiate the extent to which an innovation spurs subsequent innovations (e.g., Ahuja & Lampert, 2001; Cattani, 2005). To distinguish between new entrants and incumbents, we created the dummy variable *New entrant* set to 1 if the focal patent was issued to a firm whose first patent was within solar energy, thus indicating that the firm started innovation activities in this setting. We operationalized a firm's generative appropriability by calculating the extent to which other firms capture the technological opportunities that the focal firm's innovations spawn relative to opportunities captured by the focal firm itself. The variable *low generative appropriability* will have higher values the more other firms capture these opportunities, it is: when the focal firm has lower levels of generative appropriability. Litigiousness is measured as the proportion of the firm's

10.5465/AMBPP.2021.142

patents the firm claimed an infringement for. We consider several control variables and include year dummies.

Table 1 about here

Table 1 presents the Random-Effects OLS estimates of the effect on the number of citations received (entered as natural logarithm of the original values added by one) by a new entrant's patent. Model 2 reveals that the coefficient on *New entrant* is positive ($\beta = 0.08$; $p = .00$), indicating that the number of citations that new entrants' patents receive in any of the nine years following their respective application year is on average 8% higher than the number of citations received by similar patents created by incumbents. This finding provides support for H1. Model 3 shows that the coefficient on the interaction *New entrant* X *Low generative appropriability*, which corresponds to the contingency effect in H2, is positive ($\beta = 0.09$; $p = .05$). A one-standard-deviation increase in *Low generative appropriability* leads to a 11.3% higher number of citations received by a new entrant's patent compared to its counterfactual patent generated by an incumbent. Model 4 shows that the coefficient on the interaction *New entrant* X *Litigiousness*, which relates to the contingency effect that H3 predicts, is also positive ($\beta = 1.24$; $p = .00$). A one-standard deviation increase in value for *Litigiousness* results in a 14.2% increase in the number of citations received by a new entrant's patent relative to a similar patent of an incumbent.

DISCUSSION AND CONCLUSION

Our study's main contribution is to the emerging literature highlighting knowledge spillovers as important underpinnings of the interplay between new entrants and incumbents in Schumpeterian environments (Agarwal et al., 2007, 2010; Giustiziero et al., 2019). By examining a context in which both new entrants and incumbents draw on new technologies this study aligns with recent literature shifting focus away from creative destruction, to propose a more comprehensive and nuanced picture of the dynamic interplay in Schumpeterian environments, which oftentimes involves both new entrants and incumbents expanding the technological frontier (Cozzolino & Rothaermel, 2018; Giustiziero et al., 2019). This shift in focus is conceptually meaningful because, arguments about incumbents benefiting from knoweldge spillovers stemming from new entrants in a creative destruction scenario (e.g., Dushnitsky & Lenox, 2005; Maula et al., 2013) have been predicated on the higher propensities of new entrants to create innovations that have a higher potential for spawning subsequent innovations in the first place (Rosenkopf & Nerkar, 2001; Polidoro & Yang, 2020). Lacking was an investigation of whether, and the factors why, innovations created by new entrants contribute to spurring subsequent innovations more than similar innovations created by incumbents. By focusing on creative construction, we fill this important conceptual void and show that, even when new entrants and incumbents draw on radical departures of existing technologies and accordingly generate knowledge spillovers (Agarwal et al., 2010), important asymmetries exist in the extent to which other firms benefit from those spillovers (Knott, Posen, & Wu, 2009).

REFERENCES AVAILABLE FROM AUTHORS

10.5465/AMBPP.2021.142

Table 1 Patent random-effect OLS estimates of influences on a patent's *Citations received*

Variables	Model 1	Model 2	Model 3	Model 4
New entrant (H1: $\beta > 0$)		0.08	0.08	0.08
		(0.00)	(0.00)	(0.00)
New entrant X Low generative appropriability (H2: $\beta > 0$)			0.09	
			(0.05)	
New entrant X Litigiousness (H3: $\beta > 0$)				1.24
				(0.00)
Low generative appropriability	0.02	0.02	0.02	0.02
	(0.44)	(0.44)	(0.53)	(0.46)
Litigiousness	0.15	0.19	0.18	0.54
	(0.58)	(0.46)	(0.51)	(0.00)
University endorsements of innovations	0.05	0.06	0.06	0.06
	(0.00)	(0.00)	(0.00)	(0.00)
Scientific endorsement of products	-0.03	-0.05	-0.05	-0.06
	(0.21)	(0.05)	(0.05)	(0.01)
Non patent backward citations	-0.01	-0.01	-0.01	-0.01
	(0.02)	(0.01)	(0.01)	(0.01)
Patent originality	0.04	0.02	0.02	0.02
	(0.44)	(0.69)	(0.73)	(0.63)
Patents	-0.04	-0.04	-0.05	-0.04
	(0.00)	(0.00)	(0.00)	(0.00)
Intrafirm collaboration	-0.02	-0.02	-0.02	-0.02
	(0.00)	(0.00)	(0.00)	(0.00)
Inventors	0.01	0.02	0.03	0.02
	(0.13)	(0.03)	(0.02)	(0.04)
Alliances	-0.00	-0.00	-0.00	-0.00
	(0.62)	(0.63)	(0.63)	(0.68)
Firm density	-0.00	0.00	0.00	0.00
	(1.00)	(0.80)	(0.91)	(0.80)
Year dummies	YES	YES	YES	YES
Constant	0.06	0.04	0.03	0.04
	(0.04)	(0.28)	(0.34)	(0.24)
Observations	3,674	3,674	3,674	3,674
Wald x^2	125.0	127.6	127.6	9285

p values in parentheses. Robust standard errors, clustered on patent level.