Does pre-entry licensing undermine the performance of subsequent independent activities? Evidence from the global aerospace industry, 1944-2000

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RESEARCH NOTES AND COMMENTARIES

DOES PRE-ENTRY LICENSING UNDERMINE THE PERFORMANCE OF SUBSEQUENT INDEPENDENT ACTIVITIES? EVIDENCE FROM THE GLOBAL AEROSPACE INDUSTRY, 1944–2000

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We study how firms' use of in-licensing for their initial entry to a business domain can detract from the performance of their subsequent autonomous endeavors in the domain. We argue that in-licensing produces high levels of causal ambiguity about factors that drive the performance achieved with the licensed product. In turn, the experience that firms gather through pre-entry licensing is likely to generate superstitious learning and overconfidence that undermine the performance of licensees' subsequent independent operations. The biases will be particularly strong in the face of contextual dissimilarity. We find consistent evidence in a study of firms that entered the global aircraft industry between 1944 and 2000. The research helps advance the understanding of the benefits and costs of markets for technology. Copyright © 2012 John Wiley & Sons, Ltd.

INTRODUCTION

A growing body of research highlights the importance of markets for technology (Arora, Fosfuri, and Gambardella, 2001; Prencipe, Davies, and Hobday, 2003), but work to date has not considered how the decision to in-license products in a new business domain might affect licensees' subsequent ability to compete on their own and, hence, the success of independent products they later offer in the same domain. Some arguments suggest that experience from initial in-licensing may contribute to the success of later independent ventures (Atuahene-Gima, 1992; Zahra and Nielsen, 2002). By contrast, this paper draws on the experiential learning literature (Levitt and March, 1988; Mowery, Oxley, and Silverman, 1996; Zollo and Reuer, 2010) to argue that launching new goods and services via in-licenses generates biases that may actually inhibit the success of subsequent independent products.

This study compares the performance of the first independent products of firms that enter a new business domain with or without pre-entry licensing. For independent entry without pre-entry licensing, firms establish initial operations in a

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domain by developing, purchasing, and bundling the resources they need to introduce their first products (Mitchell and Singh, 1992); with pre-entry licensing, firms enter a new domain by initially contracting to manufacture and commercialize another firm's product (Atuahene-Gima, 1992).[1] Data from the global aerospace industry between 1944 and 2000 demonstrate lower success of independent products for firms that first undertake pre-entry licensing, particularly as contextual dissimilarity between the licensed and independent products increases. The analysis controls for the endogeneity of entry strategy choices. The research highlights the idea that experiential biases may constrain potential benefits of markets for technology.

MARKETS FOR TECHNOLOGY AND EXPERIENTIAL LEARNING

Ongoing research has emphasized the importance of markets for technology, most commonly considering the supply side of the market. Gallini (1984) suggested that firms may sell their technology to deter entry. Teece (1986) argued that licensing becomes feasible when intellectual property regulations help potential licensors protect their property rights. Arora and Fosfuri (2003) and Fosfuri (2006) developed a model where out-licensing decisions reflect a trade-off between gaining revenues from licensing payments and losing profits due to increased competition. A few studies have begun to consider the demand side for technology licenses. Cassiman and Veugelers (2006) found that firms tend to view internal research and development (R&D) and external in-licensing as complements. Hobday and several co-authors highlight the role of systems integrators in combining technology from suppliers (see Hobday, Davies, and Prencipe, 2005). Brusoni and Prencipe (2001) and Brusoni, Prencipe, and Pavitt (2001) argue that external sourcing requires strong coordination skills for both knowledge development and knowledge assembly. Nevertheless, studies of markets for technology are only beginning to assess whether in-licensing offers access to resources that contribute to later independent activities of the licensee.

Strategic management research sheds light on how in-licensing affects subsequent performance, but does not fully answer the question. Transaction cost theory argues that using external or internal knowledge generates equivalent performance as long as firms select sourcing modes that minimize production and transaction costs (Williamson, 1991; Leiblein, Reuer, and Dalsace, 2002), but this conclusion focuses on the performance of focal transactions rather than considering how governance choices for one set of transactions might affect the performance of later transactions. Studies of post-licensing performance offer conflicting conclusions, identifying opportunities to use in-licenses to gather resources that firms need to operate in a domain (Zahra and Nielsen, 2002; Zahra, Keil, and Maula, 2005) but also highlighting constraints on subsequent independent activities when licensees gain only limited access to licensors' knowledge (Mowery *et al*., 1996; Steensma and Corley, 2000; Anand and Khanna, 2000). Across these studies, whether in-licensing offers sufficient access to new resources to enhance later independent activities remains an open question.

The experiential learning literature offers insights that can help answer this question, identifying both benefits and constraints of experience. Traditional arguments suggest that accumulated experience helps firms make inferences about the effectiveness of activities (Argote, 1999), thereby avoiding processes that proved harmful and implementing needed actions more rapidly (Greve, 1998). Several studies show that production costs often decrease as firms gain experience in producing a given good (Lieberman, 1989) and that technical capabilities increase with experience (Moorman and Miner, 1997; Nerkar and Roberts, 2004).

By contrast, other arguments about organizational experience suggest that causal ambiguity may cancel many of the benefits of experiential learning and can even bias future activities. Causal ambiguity means that it is difficult to determine what factors produce an outcome (Reed and DeFillippi, 1990). Levitt and March (1988) argued that firms often draw false inferences about what factors cause specific outcomes when they gather experience in situations involving high levels of causal ambiguity, thereby inhibiting effective learning and instead generating superstitious

[1] Hybrid modes combine internal and contractual exchanges in varying ways (Williamson, 1991; Hennart, 1993); we compare independent and licensing entry, while controlling for collaborative entry.

learning. In turn, they contend that superstitious learning results in overconfidence because decision makers inappropriately believe they understand the causal relationships. Overconfidence then harms subsequent performance because it leads firms to take actions based on capabilities they do not possess. Several scholars suggest that overconfidence can damage the performance of acquisitions (Haleblian and Finkelstein, 1999; Hayward, 2002), alliances (Tyler and Steensma, 1998), international expansion moves (Nadolska and Barkema, 2007; Petersen, Pedersen, and Lyles, 2008), and new product introductions (Simon and Houghton, 2003).

Overall, the experiential learning arguments suggest an intriguing implication concerning the relative success of subsequent independent efforts by experienced and inexperienced firms. Experience that firms gather in situations involving substantial causal ambiguity produces superstitious learning and results in overconfidence, which leads them to apply lessons they believe they have learned and to take inappropriate actions that can damage future success. Conversely, decision makers in firms with no experience to draw upon have fewer biases regarding the causes of performance when they engage in a new activity and are more likely to recognize that their firm needs to develop new skills that suit the context. The inexperienced firms will spend more effort planning activities in the new domain because they better recognize the technological and commercial challenges they face. Hence, inexperienced firms may actually achieve better performance than firms that have accumulated experience in contexts involving high levels of causal ambiguity. As we discuss next, the drawbacks of experience gathered in contexts with substantial causal ambiguity are relevant when analyzing how in-licensing in the markets for technology will influence the performance of subsequent internally developed initiatives.

HYPOTHESES: PRE-ENTRY LICENSING AND EXPERIENTIAL LEARNING

We argue that entry into a new business domain by in-licensing technology is particularly conducive to superstitious learning and overconfidence, undermining the performance of subsequent independent projects. A licensee carries out only a subset of tasks necessary to introduce a new product (e.g., manufacturing, assembly, and sales), while the licensor undertakes many of the critical tasks, such as technological development and product design (Arora *et al.*, 2001; Fosfuri, 2006). As a result, licensees gather experience about only a subset of the required tasks. The separation of the outlicensing and in-licensing organizations inhibits the transfer of knowledge about the tasks; tacitness and organizational embeddedeness limit the ability to transfer knowledge across organizational boundaries (Kogut and Zander, 1992), while appropriation concerns limit the incentives of the licensor to reveal knowledge (Teece, 1986). Although a licensee will gain some knowledge about a licensor's activities, most learning that takes place about these activities will be indirect and partial, through observation rather than hands-on experience (Zollo and Singh, 2004).

The idea of partial learning also arises in work by scholars such as Nelson (2000) and Pavitt (1998) that distinguish between bodies of understanding (knowledge of technology) and bodies of practice (applications of the technology to specific products). In-licensing may help firms develop some knowledge about identifying market opportunities and manufacturing and commercializing licensed products. However, licensees do not perform the tasks related to developing the technologies embodied in the licensed products. In turn, organizational separation between licensor and licensee limits the access of licensees to the scientific and technological knowledge underlying independent operations in the domain. Hence, experience in practice with particular products may provide a first step toward acquiring such knowledge, but the in-depth understanding needed for independent new product development is likely to be incomplete.

The partial learning from in-licensing can create causal ambiguity about factors that led to the success or failure of the licensed products. Accurate understanding of causal relationships between actions and outcomes will arise primarily for those tasks the focal firm undertook, while causal drivers for tasks the licensor carried out will remain ambiguous. Furthermore, because the performance of licensed products results from a combination of tasks performed by licensor and licensee, licensees will have imperfect understanding of how each task influences performance. Hence, for the licensee, the causal determinants that drive the

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performance of the licensed product will be incompletely specified.

In turn, because of the causal ambiguity, licensing experience in which firms face difficulties in correctly attributing the reasons for the performance of the licensed product to their own activities or to contributions from their licensors will tend to generate superstitious learning and overconfidence. Several studies suggest that managers often overestimate their own contributions to successful projects (Neale and Bazerman, 1985; Kim and Miner, 2007). Licensees are likely to overemphasize the value of their own contributions and downplay those of the licensor in the performance of the licensed product, thus driving them to hold unfounded beliefs about their own abilities. As a result, when developing their own independent product, earlier licensees will often attempt to perform actions they are not capable of doing well, based on skills that they do not actually possess. For instance, they may assume erroneously that they have mastered the use of particular composite materials and, in turn, may add flawed technical features to their independent product. Such inadequate actions will undermine independent success.

Hypothesis 1: Firms that enter a new business domain independently, without prior pre-entry licensing, will achieve greater post-entry performance than the first stand-alone ventures of firms that initially engaged in pre-entry licensing.

We now consider how the degree of dissimilarity between the contexts in which licensees accumulated experience and in which they undertake new activities will exacerbate the biases produced by causal ambiguity. Superstitious learning and overconfidence often cause managers to misjudge differences between new and past activities (Tversky, 1977). Greater difference between these activities is likely to increase the biases arising from misunderstood experience. Cohen and Bacdayan (1994) demonstrated that novice players out-performed individuals who had played a card game under specific rules when the rules of the game changed. Zollo and Reuer (2010) showed that banks' alliance experience reduced the performance of later acquisitions that required high levels of integration, because alliance experience provided only a limited understanding of integration processes.

Such problems will be common across generations of products because independent entry following licensed production often involves significant dissimilarity. In order to avoid cannibalization or to bypass non-compete agreements, new products often differ in design and market positioning from licensed products. Differences between licensed products and later independent products tend to be common in product systems industries such as aircraft manufacturing. In order to meet new customer demands, firms in these industries commonly upgrade their products by adding modules and components to the core architecture of existing products (Miller *et al*., 1995; Hobday, 1998); Hobday *et al*. (2005) report that the number of aircraft gas turbine parts grew from 9,000 in 1946 to 20,000 in 1957. As a consequence of such increased diversity, along with changing technological levels, complexity often increases drastically across generations of products.

Hypothesis 2: The greater the level of dissimilarity between the initial licensed product and the first independently developed product, the lower the post-entry performance of firms that initially engaged in pre-entry licensing.

In sum, the logic underlying the predictions leads from partial experience via licensing to constraints on later independent activities. Task sharing by licensor and licensee creates causal ambiguity due to organizational separation that impedes the flow of tacit information and creates concerns about intellectual property. In turn, causal ambiguity generates superstitious learning and overconfidence by the licensee. Some of the inferences that licensees draw from their licensing activities are likely to be erroneous, fostering flawed actions for future related projects. Hence, pre-entry licensing can undermine the performance of subsequent autonomous endeavors, so that experience accumulated through product in-licensing may be worse than no experience at all. The problems will be particularly severe when contextual dissimilarity exacerbates biases that arise from the inherent causal ambiguity. The Appendix contains two examples of autonomous aircraft projects that struggled despite the focal firm's earlier success with in-licensed aircraft production.

We note that the argument applies most strongly to in-licensing technology for complete products,

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as opposed to cases in which systems integrators purchase components of product systems. Brusoni *et al*. (2001: 613) indicate that '[s]ystems integrator firms ... [maintain] in-house concept design and systems integration capabilities to coordinate the work (R&D, design, and manufacturing) of suppliers.' Systems integrators that in-license components must gain an understanding of causal relationships to integrate them effectively; in doing so, they are less likely to become overconfident.

ANALYSIS

Data and method

We tested our predictions on the population of firms that operated in the aircraft industry between 1944 and 2000, examining four domains of this industry: fighters, turboprops, helicopters, and jets. We drew the data from an extensive archival study, the primary source being the *Jane's All the World's Aircraft* yearbooks for each year from 1944 to 2000 (Jane's, 1944–2000). The yearbooks provide technical characteristics and sales information for all aircraft that manufacturers produced each year, as well as the production mode of all aircraft produced in the world (internal development, alliance, or licensing). We considered a firm to have entered one of the four lines of business of the aircraft industry via independent, alliance, or licensing entry based on the firm's first listing in each domain.

Because firms with different characteristics may favor different entry strategies, we used a two-stage model to test the hypotheses (Shaver, 1998). In the first stage of the model, we used explanatory factors from transaction cost and resource-based arguments to predict entry strategies. The second stage analyzed the performance of the businesses that turned to autonomous production, using the inverse Mills ratio from the first-stage analysis to control for the endogeneity of entry strategy choices. We clustered the data by firm in both steps of the analysis; we also clustered by country in the performance models.

Entry strategy model

The first step examined factors driving entry strategy choices. The data include firms based in 27 countries with 159 entries, including 84 first entries into the industry and 75 diversifying entries by aircraft industry incumbents.[2] Firms mainly used independent (93 cases) and licensing (50 cases, from 23 out-licensors) entries,[3] plus 16 alliance entries in which firms shared design, development, and manufacturing tasks with another firm. We used ordered probit regression to examine choices among independent, alliance, and licensing entry; prior research supports the idea of ordered entry (Park and Russo, 1996).

Several firm, project, and environmental factors might influence entry mode and/or subsequent performance. *Firm size* records a firm's aircraft sales in the year before it entered a new business domain. *Technical experience* records the mean of the technical complexity of all aircraft that the focal firm had previously produced independently in any other domain. This variable helps assess firms' industrywide resources; nonetheless, while the domains draw upon similar scientific disciplines, they require different bodies of practice (Pavitt, 1998) that limit redeployability. *State-owned firm* denotes ownership by governments, which may encourage in-licensing and/or provide subsidies that attract licensors. *Product complexity* records the log of the product of the aircraft's maximum speed, range, and takeoff weight (Garrette, Castañer, and Dussauge, 2009), which helps address transaction cost and resource-based arguments about complexity (Masten, 1984; Mitchell and Singh, 1996). *Potential market size* recorded the gross domestic product (GDP) of each firm's home country in constant U.S. dollars (Maddison, 2003) because national preferences affect purchases of military and commercial aircraft.[4] *Entry year* assessed trends by recording the firm's first year in the business domain. Categorical variables recorded the *fighter, turboprop, helicopter*, and *jet* domains.[5]

[2] Entries: Argentina (2), Australia (4), Belgium (1), Brazil (3), Canada (6), Chile (1), China (1), Egypt (3), Finland (4), France (11), Germany (10), India (3), Indonesia (2), Israel (2), Italy (8), Japan (14), Korea (3), Holland (4), Singapore (2), South Africa (2), Spain (4), Sweden (2), Switzerland (3), Taiwan (1), Turkey (1), United Kingdom (19), United States (43).

[3] Of the 50 in-licensees, 34 were start-ups or diversifying entrants, while 16 were aircraft incumbents; none of the in-licensees had prior out-licensing experience.

[4] For 2000 (when comparable data were available), regressing national GDP against military budget (SIPRI, 2000) and aircraft inventories of airlines based in the country (FI/DMS, 2000) yielded $R^2 = 92$ percent.

[5] We assigned 'trainer' aircraft as follows: jet-propelled (e.g., Northrop T-38/F-5; Lockheed T-33; AlphaJet) with fighters;

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Four variables served as instruments that might affect entry strategy but do not affect subsequent performance. *Bandwagon effect* records the number of autonomously developed products commercialized in the focal business domain, which could increase the pool of potential licensors (Zahra *et al*., 2005). *Military design* is a dummy variable that controls for national security concerns that might result in military aircraft being more likely to be developed independently. *Demand uncertainty*, which may favor internal development (Heide and John, 1990), records the standard deviation of the firm's home country GDP over the five years prior to project launch; assessing prior demand volatility is a common measure of market uncertainty (Leiblein and Miller, 2003; Robertson and Gatignon, 1998). *Firm's other aircraft businesses* records the number of businesses that the firm has in the aircraft industry among the fighter, turboprop, jet, and helicopter domains; this variable helps assess transaction cost arguments concerning resource redeployability, although inter-domain differences in knowledge of practice and technology may restrict fungibility (Pavitt, 1998).

Independent entry success model

The second stage of the model examines the influence of entry strategy on independent performance, while controlling for the endogeneity of entry strategy choices. The sample includes 113 cases in which firms achieved independent entry in one of the four business domains. Each of these firms independently produced aircraft in the domain, either as their first foothold (93 cases) or after having initially operated through in-licensing (16 cases). We also included four cases in which firms entered independently after undertaking pre-entry alliances. We expect the impact of alliance entry to fall between independent and licensing entry because collaboration lies within a continuum between hierarchy to contracts (Williamson, 1991); the small number of cases allows for exploratory analysis. We treated acquisition entries (12 cases) as continuing operations at the business level. The performance analysis excluded the 46 cases in which firms undertook pre-entry licensing or alliances but did not later develop an independent aircraft of their own; 37 of the 46 firms exited the industry before creating independent operations in the new business domain, while nine were still operating through licensing or alliances at the end of the study period.[6]

We measured post-entry success by cumulative *unit sales* of the first independent aircraft in the new domain. Sales volume has long been a key indicator of profitability in the aircraft industry owing to the high level of fixed costs required to initiate a program (Wright, 1936). To avoid mid-program bias, we estimated unit sales for the 27 aircraft projects for which production had not been terminated by the end of the study period with the yearly production schedule of the 86 programs that reached the end of their production life by 2000.[7]

Two sets of independent variables test the hypotheses. For Hypothesis 1, dummy variables record entry strategies (*independent entry, licensing entry, alliance entry*). For Hypothesis 2, *technical complexity increase* records the magnitude of the difference in complexity between the product(s) that a firm introduced in its pre-entry licensing phase and its first independently developed product; this variable records the difference in complexity between the most complex licensed product and the first independent product.[8]

The performance models include multiple controls. Several variables from the entry strategy model might influence performance, including *firm size, technical experience, product complexity, potential market size, entry year, aircraft domain*, and *state ownership. Number of competitors* may reduce sales of any aircraft project. *Development time* indicated the marginal development cost of the firm's first independent project in the

props (e.g., Beechcraft T-34 and T-6 Texan II; Embraer Tucano) with turboprops.

[6] It is not possible to use a selection analysis of ultimate independent entry as a first stage in the performance model because firms that chose initial independence by definition also achieve subsequent independence. Separate logit analyses identified three factors that influenced independent entry following alliances or licenses: greater sales of the licensed or alliance product, earlier entry into the domain, and better economic conditions.

[7] On average, aircraft projects achieved six percent of their total production at the end of the first year of production, 13 percent at the end of Year 2, 68 percent at the end of Year 10, and 86 percent at the end of Year 15.

[8] *Technical complexity increase* has large value when a former licensee introduces an aircraft that is much more complex than the pre-entry licensing aircraft; for example, when a licensee of Cessna-type aircraft introduces a Hercules-type turboprop. In contrast, low value indicates that the focal autonomous aircraft is less complex than the licensed aircraft; for example, when a former licensee of a Hercules-type turboprop introduces a Cessna-type aircraft.)

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Table 1. Descriptive statistics (N = 113)

ID	Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	Unit sales	1																							
2	Firm size	−0.07	1																						
3	Product complexity	−0.04	0.46*	1																					
4	Potential market size	0.11	0.06	−0.19*	1																				
5	Firm technical skills	−0.10	0.69*	0.40*	0.11	1																			
6	Year	−0.27*	−0.05	−0.32*	0.32*	0.14	1																		
7	Helicopter	0.15	−0.12	−0.60*	0.27*	−0.11	0.25*	1																	
8	Fighter	0.08	−0.26*	0.13	−0.24*	−0.25*	−0.38*	−0.29*	1																
9	Jet	−0.04	0.38*	0.47*	0.15	0.38*	0.05	−0.18	−0.32*	1															
10	Prop	−0.16	0.04	−0.05	−0.08	0.03	0.16	−0.30*	−0.53*	−0.33*	1														
11	Number of competitors	−0.28*	−0.28*	−0.18	−0.11	−0.13	0.40*	−0.26*	0.32*	−0.38*	0.18	1													
12	State-owned firm	−0.16	−0.09	−0.13	−0.32*	−0.06	0.28*	0.06	−0.07	−0.10	0.10	0.19*	1												
13	Demand uncertainty	0.26*	−0.11	0.14	−0.05	−0.15	−0.44*	−0.13	0.43*	−0.15	−0.21*	−0.28*	−0.10	1											
14	Firm's other aircraft businesses	−0.16	0.56*	0.20*	0.04	0.70*	0.27*	−0.01	−0.19*	0.33*	−0.06	−0.03	0.02	−0.22*	1										
15	Bandwagon effect	−0.29*	−0.27*	−0.19*	−0.02	−0.08	0.55*	−0.18	0.22*	−0.22*	0.09	0.95*	0.16	−0.35*	0.03	1									
16	Military design	0.08	−0.11	−0.13	−0.34*	−0.16	−0.15	0.02	0.51*	−0.48*	−0.14	0.27*	0.16	0.24*	−0.08	0.19*	1								
17	Licensor scope	−0.12	−0.04	−0.14	−0.10	−0.07	0.22*	0.23*	0.13	−0.17	−0.16	0.19*	0.34*	−0.08	0.07	0.22*	0.23*	1							
18	Development time	−0.28*	−0.15	−0.17	−0.11	−0.13	0.30*	0.16	0.12	−0.24*	−0.04	0.33*	0.31*	−0.18	0.09	0.34*	0.25*	0.14	1						
19	Independent entry	0.14	0.03	0.07	0.17	0.07	−0.21*	−0.14	−0.16	0.21*	0.10	−0.25*	−0.24*	0.10	−0.11	−0.26*	−0.23*	−0.82*	−0.12	1					
20	Alliance entry	−0.06	0.00	0.02	−0.08	0.03	0.15	−0.08	−0.04	−0.09	0.16	0.13	−0.09	−0.05	0.18	0.13	0.04	−0.07	0.07	−0.41*	1				
21	Licensing entry	−0.13	−0.03	−0.09	−0.15	−0.10	0.15	0.20*	0.19*	−0.18	−0.19*	0.20*	0.31*	−0.08	0.02	0.21*	0.24*	0.94*	0.09	−0.88*	−0.08	1			
22	Technical complexity increase	0.05	−0.04	0.25*	0.02	−0.02	−0.17	−0.05	0.01	0.07	−0.03	−0.04	−0.13	0.03	−0.22*	−0.02	−0.11	−0.22*	−0.05	0.34*	−0.24*	−0.25*	1		
23	Initial licensing success	−0.06	0.08	−0.08	−0.13	−0.13	0.01	0.14	0.17	−0.11	−0.18	0.10	0.13	−0.04	−0.02	0.08	0.08	0.52*	0.09	−0.55*	−0.05	0.63*	−0.12	1	
24	Mills ratio	0.09	−0.28*	0.01	−0.14	−0.27*	−0.18	−0.05	0.11	−0.09	−0.01	−0.04	0.06	0.16	−0.29*	−0.08	0.02	−0.65*	0.20*	0.70*	−0.15	−0.68*	0.13	−0.47*	1
	Mean	0.82	0.16	3.97	1.29	1.45	1967	0.14	0.34	0.17	0.35	17.86	0.19	0.03	1.70	17.40	0.66	0.18	3.12	0.82	0.04	0.14	−0.06	0.06	0.23
	Std. dev.	1.86	0.26	0.95	1.38	2.10	14.29	0.35	0.47	0.38	0.48	9.95	0.40	0.03	0.85	10.88	0.47	0.47	1.62	0.38	0.19	0.35	0.39	0.25	0.62
	Min	0.01	0	2.03	0.03	0	1944	0	0	0	0	1	0	0.00	1	0	0	0	0.58	0	0	0	−2.20	0	−1.71
	Max	14.90	1.21	6.09	7.65	6.19	1999	1	1	1	1	34	1	0.17	4	39	1	2	8.84	1	1	1	1.22	1.82	2.20

Variables are estimated in the year before the first independent introduction in the business domain (* $p > 0.05$).

Table 2. How pre-entry licensing affects the performance of subsequent independent entries, controlling for influences on entry strategy

	1. Entry strategy (+ = license)		2a. Unit sales		2b. Unit sales		2c. Unit sales	
	β	s.e.	β	s.e.	β	s.e.	β	s.e.
Firm size	−1.34	1.077	−0.416*	0.227	−0.543**	0.234	−0.801***	0.211
Firm technical experience	−0.234***	0.086	−0.045	0.07	−0.088	0.078	−0.136*	0.079
State-owned firm	0.813***	0.263	0.225	0.346	0.436	0.364	0.575*	0.309
Product complexity	0.854***	0.222	0.156	0.154	0.338*	0.184	0.618***	0.206
Fighter (v. helicopter)	−1.657**	0.643	−0.656	0.564	−0.946*	0.563	−1.461***	0.476
Jet (v. helicopter)	−3.520***	0.873	−1.761***	0.664	−2.314***	0.631	−3.006***	0.587
Turboprop (v. helicopter)	−2.278***	0.616	−1.326**	0.525	−1.789***	0.52	−2.363***	0.455
Potential market size	−0.403*	0.208	0.150*	0.079	0.113	0.082	0.086	0.065
Entry year	−0.005	0.01	−0.015	0.012	−0.013	0.012	−0.014	0.012
Military design	−0.551*	0.301						
Bandwagon effect	0.032**	0.015						
Firm's other aircraft businesses	0.095	0.169						
Demand uncertainty	1.037	3.766						
Initial licensing success			−0.21	0.288	0.199	0.235	0.242**	0.111
Licensor scope			−0.470*	0.279	0.66	0.482	0.827	0.53
Development time			−0.305*	0.169	−0.327*	0.17	−0.326*	0.164
Number of competitors			−0.028***	0.006	−0.022***	0.008	−0.013*	0.007
Mills ratio (controls choice of entry strategy)			−0.029	0.126	−0.449***	0.145	−0.880***	0.231
Independent entry (vs. license): H1 +					2.543***	0.87	3.725***	0.905
Alliance entry (vs. license)					2.382**	1.021	2.909***	0.959
Contextual dissimilarity: technical complexity increase: H2 −							−0.607***	0.172
Constant			31.507	24.779	26.451	24.696	25.496	24.204
R-squared	0.3		0.23		0.24		0.25	
F	—		2.07**		1.92**		1.87**	

*** $p < 0.01$; ** $p < 0.05$; * $p < 0.10$ (two-tail tests).

NOTES

a. Model 1 (159 entries): Ordered probit clustered by firm (84); Entry Strategy is coded 1 for independent, 2 for alliance, and 3 for licensing (positive = more likely to license). This model controls for firm skills and other factors that might affect subsequent performance in the unit sales models. The significant instruments from Model 1 (military design and bandwagon effect) had no impact on performance when added to Model 2.

b. Model 2 (113 entries): OLS clustered by firm (70) and country (19) to address firm-level commonalities across business domains and common national policies (two-factor clustering is not available for ordered probit); Unit Sales records cumulative sales of the first independent project (positive = greater sales).

c. Payoffs: We used the coefficients of Model 2c to calculate the performance that firms would have achieved had they used an alternative entry strategy. Firms that chose independent or alliance entry would have achieved lower sales had they chosen licensing entry (Production = 912 units for independent or alliance entry vs. 663 for licensing entry), and firms that chose licensing entry would have achieved higher sales had they entered through an independent or alliance entry (Production = 240 units for licensing entry vs. 870 for independent or alliance entry).

d. Sensitivity analyses: The results are robust to alternative methods (GLS and random effects regression); performance based on the sales value of the first autonomously developed product (we used price estimations specified in the Aerospace Systems Group Library (FI/DMS, 2000); increased technical complexity based on the least complex licensed product or using ratios rather than differences in complexity; adding controls for military budgets, economic climate, elapsed time between license and independent entry, number of in-licenses, and number of competing products; assessing survival of independent entrants; and comparing the performance of first and second independent entries.

new business domain (Kessler and Chakrabarti, 1996), to address the possibility that licensees may have made investments that they can redeploy toward later independent products and so might launch products with more limited market potential because fewer sales are needed to recoup the marginal investment made when entering independently (although it seems unlikely that firms use

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pre-entry licensing primarily when they expect to launch later projects with limited market potential). *Initial licensing success* recorded unit sales of the licensed product with which the firm entered in the domain, as a control for firm skills. *Licensor scope* recorded the number of domains in which a licensor operated when it granted a license (zero for independent entries), in case broad-based licensors pick licensees they expect to achieve limited independent sales. The *Mills ratio* from the first-stage model controls for the endogeneity of entry strategy choices. Table 1 reports descriptive statistics.

RESULTS

Table 2 presents the first and second stages of the treatment effect model. Model 1 assesses factors that affect the choice of entry strategy. Firms with greater technical experience, access to a larger market, and military products tend to select independent entry; product complexity, state ownership, bandwagon effect, and helicopters favor licensing entry. Model 1 correctly predicts the entry strategy of 113 of the 159 observations of our sample (82% of the independent entries and 64% of the licensing entries). Two instruments (military design and bandwagon effect) affect entry choice; they did not affect subsequent unit sales. Models 2a to 2c report the controls and predictors from the performance analysis.

The results in Models 2b and 2c of Table 2 support both hypotheses. Consistent with Hypothesis 1, firms that enter a new business domain through initial licensing achieve lower success with their first independent product than firms that immediately opt for independent entry (Model 2b: $\beta = 2.543$, $p < 0.01$). Licensing entry also underperforms the cases that undertook alliance entry (Model 2b: $\beta = 2.382$, $p < 0.05$); alliance entry has a smaller coefficient than independent entry although the difference is not significant. Consistent with Hypothesis 2, Model 2c indicates that *technical complexity increase* has a negative impact on the sales of the first independently developed product introduced by former licensees ($\beta = -0.607$, $p < 0.01$); the main effect of licensing entry continues to be negative ($\beta = 3.725$, $p < 0.01$).

As we report in the 'payoff' footnote of Table 2, the results suggest that firms that chose independent or alliance entry would have achieved lower sales had they chosen licensing, while firms that chose licensing entry would have achieved higher sales had they entered independently or via alliance. The second point is intriguing, because it suggests that many licensing entries are mistakes. Of course, the analysis may omit factors that provided strong barriers to independent or alliance entry, but the core point is that firms need to look hard for avenues to independent or alliance entry before settling for pre-entry licensing.

Several control variables affected performance. Complex products, state-owned firms, firms with greater sales from their licensed products, and helicopters achieved greater sales of their first independently produced aircraft. Sales declined with the number of competitors, firm size, technical experience, and development time. The Mills ratio was significant.

The results were robust. The 'sensitivity analyses' footnote to Table 2 summarizes alternative methods, dependent variable, and controls. We also calculated a survival model to ensure that the superior performance of independent entry did not mask a risk of early failure for independent entrants; instead, we found that initial independent entries survived at least as long as pre-entry licensors that later introduced independent products. One might argue that the negative impact of pre-entry licensing could arise from resources that have become obsolete in the environment in which the independent products are launched, reflecting competency traps (Leonard-Barton, 1992) rather than superstitious learning and overconfidence. However, competency traps should also affect independent entries; we found no significant differences between the performance of the first products from firms that opted for independent entry and the performance of their later independent products.

DISCUSSION

We started by asking whether pre-entry licensees tend to underperform once they undertake independent entry, as a result of superstitious learning and overconfidence produced by the partial learning from in-licensing and ensuing causal ambiguity. The results support this prediction. Firms that used pre-entry licenses achieved lower sales in their subsequent independent ventures than those that immediately undertook independent entry. The

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penalty increased with greater contextual dissimilarity, consistent with the idea that the change in context exacerbates the detrimental effect of experience involving high levels of causal ambiguity. The study suggests that licensees often develop a false sense of confidence that will in turn foster inadequate actions during subsequent independent endeavors. This illusion of knowledge and control causes the firms to trip over unexpected hurdles that may cancel benefits they derive from previously acquired experience. While licensing may enable firms to enter new domains, it often does not provide them with the resources necessary to successfully compete independently at a later stage.

The study contributes to the markets for technology literature and to the general literature on organizational learning. Arora *et al*. (2001) identify the need to determine inefficiencies as well as efficiencies in markets for technology. Yet, the literature on markets for technology has not determined whether in-licensing offers sufficient access to new resources to enhance later independent activities. The experiential learning literature helps us develop logic concerning possible answers to the question. Drawbacks of experience in contexts with high levels of causal ambiguity are relevant when analyzing how in-licensing in the markets for technology will influence the performance of subsequent internally developed initiatives. The work extends research that suggests that technology licensing faces limits in appropriating external knowledge (Mowery *et al*., 1996), developing competitive advantage (Steensma and Corley, 2000), and accumulating experience (Anand and Khanna, 2000).

Strikingly, we show that rather than simply not offering advantages, in-licensing may actually create disadvantages for subsequent independent activity. Thus, although firms may choose to in-license technologies to overcome entry barriers, the implication of this choice for long-term performance and survival is not neutral. We uncover an imperfection of the markets for technology by highlighting that in-licensing may undermine the performance of subsequent in-house efforts if it provides firms with an imperfect understanding of the knowledge critical to the area of business.

In turn, the results suggest that manufacturing complex products often does not provide a clear understanding of the scientific and technological disciplines embodied in the products. This point highlights the dual importance of bodies of understanding and practice (Pavitt, 1998; Nelson, 2000). Firms require both types of knowledge to undertake successful expansion beyond an initial license, but in-licensing activities provide only constrained experience in understanding the underlying technology. Brusoni and Prencipe (2001: 202–203) argue that integrating modules and components purchased from specialized suppliers does not substitute for creating internal bodies of understanding, so that systems integrators need to 'retain, in-house, a fundamental and integrated understanding of what they outsource.' Our study takes a step further. We suggest that firms that focus on bodies of practice may face difficulties in subsequently developing bodies of understanding because relying on bodies of practice alone can lead firms to develop spurious knowledge about the causal drivers of performance in the domain. This issue is increasingly important for convergent products in industries such as telecommunications, life sciences, and media, where firms may struggle to gain sufficient understanding of in-licensed complementary technology as they respond to the need for technological combinations that respond to competitive and market dynamics.

We also contribute to organizational learning research by providing further evidence that attempts to gain experiential learning may hinder performance of later endeavors. Experiential learning can be misleading when inferences from past actions generate superstitious learning, which will be particularly common when firms gather experience in contexts characterized by high levels of causal ambiguity. In such situations, experience may lead firms to develop a false sense of confidence and to overestimate the extent to which they can solve the challenges they face and, ultimately, to undertake inadequate actions. Our study complements recent work on the performance impact of experience in business activities such as corporate acquisitions. This work suggests that a lack of understanding of the cause-effect relationships in acquisitions is the primary reason for the limited benefits that experience with acquisitions provides (e.g., Haleblian and Finkelstein, 1999; Hayward, 2002; Nadolska and Barkema, 2007; Zollo, 2009). Our study suggests that experience may not only fail to create advantages—for example, carrying out a type of acquisition successfully—but may actually create disadvantages for subsequent standalone activities.

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The managerial implication of our work is that licensing may provide a jump start in resource creation but can inhibit a firm's ability to develop the new resources it needs to operate effectively. Clearly, firms have incentives to undertake preentry licensing despite the problems that the strategy might create. Licensing helps firms gain access to other firms' resources in order to enter a new business domain; nonetheless, such a strategy may inhibit the understanding and control that a firm needs to develop the full suite of resources required for long-term success. By contrast, independent entry forces a firm to develop new resources through its own efforts, leading to greater understanding and control of those resources.

In parallel, the study suggests that incumbents can often safely out-license their products to firms that face barriers to independent entry. In doing so, they gain royalties from their licensees. Further, start-up firms will face substantial hurdles when attempting to unveil high performance independent products. Outward licensing may thus limit the emergence of strong competitors, as Gallini (1984) argued. Indeed, if licensing is unlikely to result in the emergence of strong competitors, then licensors have a strong incentive to out-license technology. In contrast, should incumbents refuse to out-license their products, start-ups might opt for independent entry and subsequently become stronger competitors. Of course, few of the newcomers may succeed in entering the business domain, but the more successful firms will, in the process, develop the resources required to establish a durable presence.

The study has limitations that suggest avenues for future research. First, we do not test the superstitious learning and overconfidence mechanisms directly; research needs to explore the causal mechanisms, perhaps via structured case studies. Second, it would be useful to investigate cases in which firms do not in-license whole products but component technologies (e.g., licensees of aircraft engine parts). Third, while the first stage of the model controls for many factors that influence entry strategy choices, future work could examine other factors. Fourth, research should examine sectors that are less driven by government policy, to assess the degree to which political decision making might shape the results. Fifth, we believe that the results generalize to situations in which licensed products are sufficiently complex to generate substantial causal ambiguity; determining boundary conditions will require studying additional industries.

Overall, the study suggests that even though preentry licensing may help firms overcome entry barriers, the strategy can undermine subsequent performance when causal ambiguity is present. This supports the idea that partial experience via in-licensing can generate superstitious learning and overconfidence that constrain firms' future independent activities. Thus, experience does not substitute for careful independent development of resources that firms need to operate in dynamic environments.

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APPENDIX: EXAMPLES OF TROUBLED AUTONOMOUS AIRCRAFT PROGRAMS FOLLOWING SUCCESSFUL LICENSES

The two examples below describe cases in which firms that successfully introduced in-licensed aircraft faced major problems when they moved to autonomous development and production in the same domain. In both cases, industry observers have suggested that some of the problems stemmed from attempting to apply ideas from the licensed product that did not suit the independent design.

Canadair CL-41: Canadair was a Canadian aerospace firm that successfully introduced two fighter aircraft models through in-licensing: the CL-13 (a license-built F-86 Sabre from North American Aviation) in 1949 and the CL-30 (a license-built Lockheed P-80/T-33) in 1952. Encouraged by the success of these two aircraft (sales eventually totaled 1,815 and 656 units, respectively), Canadair decided in 1955 to develop its own design for a third aircraft, the CL-41 Tutor. The CL-41 project was plagued by stability problems, stemming in part from a change in engines from the prototype stage to the production stage. Problems with spin recovery forced Canadair to redesign the tail, changing from a cruciform tail, which it had carried over from its licensed projects, to a more appropriate T-tail design. Full production of the CL-41 was delayed until 1963, and orders never met projections. In 1966, Canadair terminated production of the CL-41 after building only 212 aircraft and returned to in-licensing for its next aircraft, a version of the Lockheed F-104. Canadair never attempted to independently develop another fighter and eventually exited the market.

We were able to contact an engineer who had worked with Canadair in the early 1960s, to gather insights about the company's programs. He said that Canadair had initially encountered challenges during the in-licensing programs. For the CL-13 project, some of North American Aviation's subcontractors were unwilling to divulge details of their technologies, so that Canadair had to establish domestic sources of supply (Canadian national policy also preferred domestic supply); the CL-30 program initially faced challenges in installing a powerful engine. Nonetheless, Canadair successfully overcame these challenges with the in-licensed programs. Our respondent believed that the successful experience both contributed to the decision to undertake the independent CL-41 project and provided multiple skills that were critical for the independent project, including the domestic supply base and production skills.

The engineer said that the independent CL-41 project faced at least two substantial challenges. The first was an unfortunate choice of a heavy engine that required extensive design changes to the plane—and in particular to the tail section of the plane—in order to accommodate the extra weight (the same company that supplied the engine for the in-licensed CL-13 was chosen as the supplier for the CL-41 program, which required much less thrust and consequently a different engine). The second challenge was a slower than expected transition from prototype to production scaling. In part, both of these problems reflect incomplete learning from the in-licensed programs: The success of the supplier of the engine for the in-licensed F-86 created an expectation that it would be equally successful in the new program, at least on the part of some decision makers (our respondent noted that some engineers preferred a different engine, but were overruled in the selection process); similarly, the success of the in-licensed programs generated expectations that the transition from prototype to production would go smoothly. The case illustrates the potential for overconfidence to arise across a broader set of stakeholders because political decision makers as well as company engineers influenced design choices for the independent project.

AIDC Indigenous Defence Fighter: In 1974, AIDC in Taiwan successfully introduced a licensed version of the Northrop F-5 fighter, achieving sales of almost 300 aircraft by the end of production in 1986. After the United States established formal relations with the People's Republic of China and ended the Mutual Defense Treaty with Taiwan in 1980, President Chiang Ching-Kuo of Taiwan decided to expand the local defense industry and in August 1980 requested that AIDC design an interceptor. The ensuing Indigenous Defence Fighter (IDF) project faced numerous developmental and operational problems, some of which observers believe occurred because AIDC attempted to apply ideas from the F-5 design that did not suit the new fighter. Problems included unstable pitch and underestimating necessary engine thrust, as

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well as crashes of prototypes due to apparent problems with transonic buffeting and fuel systems. AIDC began delivering the aircraft in 1994, but the Republic of China (Taiwan) Air Force subsequently reduced its orders of IDFs dramatically, deciding instead to purchase F-16s from the United States and Mirage 2000 fighters from France.

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