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Strategic switchbacks: Dynamic commercialization strategies for technology entrepreneurs

Matt Marx [a,*], David H. Hsu [b]

[a] 100 Main St., E62-478, Cambridge, MA 02142, USA
[b] 2028 Steinberg Hall – Dietrich Hall, 3620 Locust Walk, Philadelphia, PA 19104, USA

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ABSTRACT

We present a synthetic framework in which a technology entrepreneur employs a dynamic commercialization strategy to overcome obstacles to the adoption of the firm's ideal strategy. Whereas prior work portrays the choice of whether to license a new technology or to self-commercialize as a single, static decision, we suggest that when entrepreneurs encounter obstacles to their ideal strategy they can nevertheless achieve it by temporarily adopting a non-ideal strategy. We refer to the sequential implementation of commercialization strategies, in which the first strategy enables the second, as a switchback—reminiscent of zigzag paths that enable passage up steep mountains. We analyze conditions under which switchbacks can be effective in enabling the entrepreneur's ideal commercialization strategy given the attending costs, risks, and likely incumbent response.

1. Introduction

Commercializing a technical innovation can involve severe challenges no matter which strategic path the entrepreneur is contemplating. Many startups aspire to compete directly in the product market but lack the complementary assets that would allow them to do so effectively. Others seek to cooperate with incumbents in bringing new technologies to market, but find that prospective partners are deterred by uncertainty regarding the technical and commercial viability of the innovation as well as by the startup's own lack of reputation.[1] As a consequence, both the choice and the execution of commercialization strategies for entrepreneurs may be less straightforward than has been theorized to date.

An extensive literature in economics and the management of technology investigates conditions under which an invention should be self-commercialized rather than brought to market in cooperation with partners. Anchored in the analysis of arm's-length contracting versus vertical integration (e.g., Williamson, 1985; Hart, 1995; Aghion and Tirole, 1994), both theoretical and empirical work has investigated the optimal conditions and contracts for licensing (Katz and Shapiro, 1985; Kamien and Tauman, 1986; Gallini and Wright, 1990; Lerner and Merges, 1998) as well as how markets shape the risk of expropriation (Anton and Yao, 1994). Securing intellectual property rights may be necessary for licensing (Gans et al., 2008) but not sufficient (Arora and Ceccagnoli, 2006) unless complementary assets are lacking. Moreover, the commercialization decision is complicated by the fact that licensing revenues can dissipate otherwise-attainable profits (Fosfuri, 2006); the innovator must take into account product differentiation, market-share, and both upstream and downstream competition in the market for technology. Much of this literature examines the behavior of large R&D labs, for whom a single commercialization strategy may suffice given that their resources and reputation enable them to successfully execute either cooperation or competition. But even when scholars have focused specifically on technology entrepreneurs, their analysis yields static strategic prescriptions based largely on the commercialization environment (Gans et al., 2002; Gans and Stern, 2003).

We conceptualize the challenge of executing a strategy as scaling an incline with a steep grade. When a hill is too steep to be climbed directly – an especially apt analogy for typically resource-poor entrepreneurs – an alternative is to construct a switchback. Perhaps best known in the case of mountain trains such as the Darjeeling Express, a switchback involves traveling sideways up the incline at a lower grade than if attempting to climb directly up. At some point, the train stops and backtracks before continuing up the incline at a similarly-reduced grade in the opposite direc-

* Corresponding author.
E-mail addresses: mmarx@mit.edu (M. Marx), dhsu@wharton.upenn.edu (D.H. Hsu).

[1] We follow the convention in related literature of adopting a wide definition of "cooperative" strategy, including various forms of joint commercialization such as technology licensing and alliances.

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tion. Llobera and Sluckin (2007) show that while direct paths are most efficient for climbing gentle grades, sufficiently steep grades can only be scaled using switchbacks. Similarly, we suggest that entrepreneurs aspiring to a particular commercialization strategy but facing a steep climb may construct a "strategic switchback." In this approach, they initially pursue a non-ideal strategy – but only on a temporary basis – in order to eventually enable their ideal strategy.

We provide a synthetic framework that introduces two switchback strategies which depend on both the entrepreneur's ideal commercialization path and obstacles to executing it. A temporary cooperation switchback applies when entrepreneurs want to self-commercialize but are initially blocked from doing so, often for lack of complementary assets. Here, the entrepreneur uses an initial cooperative strategy to gather the resources and expertise necessary to develop or acquire the needed complementary assets, which then enables product market entry.[2] A temporary competition switchback is essential for entrepreneurs who wish to cooperatively commercialize but find themselves either unable to do so due to partner uncertainty regarding the value of the innovation, or unwilling to do so given their limited ability to negotiate attractive agreements. In this case, entering the product market demonstrates the value of the technology, builds the brand, and develops other assets needed in order to eventually achieve favorable cooperative arrangements. Switchbacks thus initially adopt a non-ideal strategy that works to mitigate existing constraints, and thereby enables transitioning to the ideal strategy.[3]

Our framework extends the literature on technology commercialization in two ways. First, whereas prior work regarding entrepreneurs (e.g., Gans et al., 2002; Gans and Stern, 2003) focuses on the role of the external environment in determining the optimal commercialization path, we identify characteristics of startups themselves that can impede their ability to implement an otherwise-desirable strategy to a greater degree than for established firms. Second, and more importantly, rather than taking these obstacles as given and unchangeable constraints leading to a permanent commercialization strategy, we propose that purposeful entrepreneurial actions can change those external constraints and thus enable the ideal strategy in the long run. We also distinguish our contribution from that of Marx et al. (2014), who provide evidence of compete-then-cooperate strategies among entrants with potentially-disruptive technologies, by sketching a broader theory of when entrepreneurs might first self-commercialize as an enabling step toward licensing—including questions of symmetric uncertainty regarding the innovation, lack of bargaining power, and waiting on intellectual property rights. Moreover, the notion of temporarily cooperating as a prerequisite to product-market entry is unique to our "switchback" formulation of dynamic commercialization strategies.

The next two sections detail first the temporary cooperation switchback and then the temporary competition switchback. In each section we discuss each switchback's benefits and costs to the entrepreneur and the likely incumbent response. Section 4 reviews boundary conditions that may reduce the viability of both types of switchbacks, and Section 5 concludes.

2. Using a temporary cooperation switchback strategy to develop complementary assets

Few inventions are attractive in isolation, and most require additional capabilities or assets for successful commercialization (Teece, 1986). Complementary assets may be other technologies which are required to build a product usable by customers – sometimes obtainable off-the-shelf, but often more specialized in that they need to be customized in order to work with the particular invention. Complementary assets in a different sense are required for marketing, distributing, and servicing a product; in some cases, regulatory approval (itself a type of complementary asset) must be obtained prior to marketing and sales.

When the cost of complementary assets is high, a product-market competition entry strategy may be infeasible for small, entrepreneurial firms. Startups may need to find ways to develop the required assets before they can compete. We see an example of this in the early history of Genentech and how its founders expected the firm's commercialization strategy to change over time as it developed complementary assets. Co-founder Robert Swanson recounts:

"It was a goal from the very beginning to make and market products as soon as we could. The first products we licensed to others. We tried to keep some manufacturing rights but let other people market. Now, why is it that you need to be an integrated pharmaceutical company? Over the long run...in order to capture all the value from the research that develops a new drug that treats a disease, you have to be able to make and sell that drug yourself, in part to control the distribution of it, not relying on someone else; and in part because you capture greater rewards by selling it yourself. Over the long run, unless you capture those rewards, you cannot invest as much in R&D that allows you to develop the second and third products...It [directly entering the product market] can't be done at once obviously, but as soon as you can I always felt that you needed to do that." (Swanson, 2000: 78–79).

Swanson's switch in commercialization strategy at Genentech was not primarily due to environmental changes but rather was part of a deliberate plan to enable the firm to eventually compete directly in the product market.[4] However, this became possible only later as the firm developed experience in navigating the process of clinical trials as well as skills in marketing and sales.

In summary, one key constraint for an emerging enterprise that aspires to enter the product market is the cost of acquiring and/or developing downstream organizational complementary assets. Note, however, that such costs can change over time—both as a result of processes outside the firm's control and as a consequence of the firm's direct actions. We discuss each of these factors in turn.

2.1. Dynamics of complementary asset development: exogenous factors

The academic literature generally assumes the cost of complementary assets to be static. In reflecting on the twenty year anniversary of Teece (1986), Chesbrough et al. (2006: 1096) remark: "Teecian complementary assets take the innovation and

[2] Although the literature routinely includes acquisition as a cooperative mode (Gans et al., 2002; Marx et al., 2014), an acquisition cannot be the first step in a switchback strategy as the firm ceases to exist.

[3] We consider commercialization strategy changes at the firm level. For single-innovation firms, this is straightforward and applies to many if not most entrepreneurial ventures. For firms with multiple innovations and/or product lines, the firm may choose different strategies for different innovations. We follow the convention that new ventures make commercialization strategy decisions for a major product line or small family of products (e.g., Gans and Stern, 2003) to make our extension to incorporate a dynamic element comparable with the prior literature.

[4] (Eventual) self-commercialization might promote increased value capture by avoiding being held up by downstream licensees (Klein et al., 1978). In addition, entrepreneurs encountering technological opportunities may generalize their innovations to a system level and may have less to gain from partnering with incumbents (Egan, 2013). There are circumstances, however, under which a first stage entrepreneurial cooperative strategy may be infeasible. When innovations are architectural (Henderson and Clark, 1990) or disruptive (Christensen, 1996), incumbent firms are likely to resist a cooperative commercialization strategy with start-up innovators.

the corresponding value chain as more or less given and consider what are the requirements for commercialization, how easy or difficult this is, and whether the inventor/innovation will profit from this and how much (absolutely and relatively). "By contrast, we suggest that the innovator need not take this cost as given but may work to lower these costs for purposes of competing, in the meantime engaging in cooperation.[5] Before discussing those efforts, we acknowledge that changes in the business environment can influence a new enterprise's commercialization strategy.

Increased availability of, or access to, complementary assets represents one class of exogenous shift affecting commercialization strategy. Examples include the emergence of lower-cost suppliers of complementary assets, such as the recent rise of biopharmaceutical clinical research outsourcing or of contract semiconductor fabrication.[6] Another is the emergence of smartphone "app stores" such as Blackberry World and Google Play, which obviated the need for developers to coordinate with device manufacturers and network carriers to launch applications. In the first case, complementary assets became available from third-party providers; in the second case, complementary assets in the form of coordinative personnel and expertise became less necessary for the entrepreneur to develop in-house. In both cases, complementary assets become less of a constraint, and the entrepreneur may have an increased ability to enter the product market directly. For example, following the rise of pure-play semiconductor foundries such as Taiwan Semiconductor Manufacturing Corporation, entrants in the semiconductor industry could feasibly concentrate on just the design phase as the basis for their new enterprise. Exogenous shifts can also work in the opposite direction, however; powerful providers of complementary assets could raise prices, making these assets more difficult to access in the market.[7] When complementary assets are inherently difficult to access or become less available over time, entrepreneurs are more likely to consider a temporary cooperation strategy than when such assets are readily available.

2.2. Temporary cooperation switchbacks as endogenously shifting the cost of complementary assets

The difficult task of acquiring (even on an evolutionary basis) such assets as manufacturing expertise or regulatory approval has not received much attention in the literature on entrepreneurial organizational development. This stands in contrast to the intensive planning efforts many technology entrepreneurs devote to devising their entry strategy and their hoped-for steady state organizational structure. In practice, the difficulties associated with this step of the entrepreneurial process can prevent startup success and in the short run insulate industry incumbents from entrant competitive pressure. However, entrepreneurs who foresee bottlenecks of this sort may devise a plan to alleviate them. If a startup can find a way to do business while acquiring the complementary assets it needs, it will be able to realize its goal of market entry in the longer term. Consider Genentech's early logic for identifying human growth hormone as a good candidate for initiating the firm's transition from cooperation to competition:

"Well, from the very beginning, I set the goal that as soon as we could, we wanted to make our own products and sell them. Obviously we couldn't do that right away. We had to be careful which products we took first to do that with. With human insulin, Eli Lilly dominated the market with 80 percent market share. It was sold through pharmacies. It would have been a very difficult product for us to take to market ourselves. On the other hand, growth hormone—which was the first product we did take through the FDA approval process and make and sell ourselves—was then being distributed by a quasi-governmental agency. . .so here was something where there were really no entrenched competitors. We had an alternative that would be safer. This was the kind of product that a small company like Genentech might be able to take to the market itself. Also, the government approval process—although more difficult than we imagined because of our naivete in terms of understanding what it took to go through that process—was straightforward in the sense that either the children were growing or not. So the end point was easy to measure." (Swanson, 2000: 77).

Note that the decision not to take human insulin to market directly—instead licensing it to Eli Lilly—probably helped the firm to focus their efforts on developing other products, in part leading to their human growth hormone product. Genentech's lead venture capitalist, Thomas Perkins, recalls: "On the license with Eli Lilly for the manufacture of insulin, there wasn't too much disagreement between Swanson and myself on that one. There was some talk, should we do it ourselves? Could we do it ourselves? But the amount of money required was just so huge." (Perkins, 2002: 8–9).

This entrepreneurial decision illustrates the idea that an entrant desiring to compete against incumbents may be initially blocked from doing so by its high cost of complementary asset acquisition, and therefore be forced to adopt a cooperative commercialization strategy. If it succeeds in lowering those costs by acquiring expertise, however, it can then switch to its ideal commercialization mode of competing against incumbents. In doing so the firm executes a *temporary cooperation switchback*: cooperating initially while learning from partners and developing complementary assets; then later, switching to a competitive strategy. Note that here the firm does not prefer cooperation but undertakes it only temporarily as a step towards its desired strategy of competing with incumbents. Pisano (2006: 87) reports on the evolving commercialization approach of Genentech in the early 1980s:

"Genentech quickly broadened its research portfolio to include an array of products. Its first annual report (1980) disclosed R&D programs in insulin (with Lilly), growth hormone (with Kabi Vitrum), thymosin alpha-1, leukocyte and fibroblast interferon (with Roche), and bovine growth hormone (with Monsanto). By 1984 the company's R&D portfolio had expanded significantly to include a broader range of therapeutic areas (tissue plasminogen activase; alpha-, beta-, and gamma-interferons; tumor necrosis factor; and factor VIII), animal health products (e.g., a foot-and-mouth disease vaccine), enzymes for food, chemical, and consumer applications (via a joint venture with Corning), instrumentation (in collaboration with Hewlett-Packard), and diagnostics (in collaboration with Baxter-Travenol). "

This suggests that 80% (four out of five) of Genentech's products in 1980 were commercialized cooperatively, whereas in 1984 the firm pursued joint commercialization for only 38% (three out of eight) of new products. This transition was surely aided by funds raised in the firm's initial public offering in 1980, but the shift may also stem from the learning afforded by early joint commercialization efforts.

Genentech was not alone in early reliance on cooperation followed by product market entry. We analyzed 169 U.S. biotechnology firms that completed an IPO, finding that once past the sample median age (7 years), they were only half as likely to enter into alliances or joint ventures (controlling for funding and patents) and also about 20% more likely to terminate existing alliances (con-

[5] For a corresponding perspective that the emergence of a market for technology may raise the value of complementary assets, see Arora and Nandkumar (2012).

[6] http://www.contractpharma.com/issues/2008-06/view_features/clinical-research-outsourcing/.

[7] Note that while the external development of complementary assets may not be truly exogenous to the focal startup in that actors may be reacting to the same signal of opportunity, we conceptualize this phenomenon as exogenous to the extent that the external providers of complementary assets are not controlled by the focal entrepreneur.

trolling for alliances entered). These suggestive results, available from the authors, are consistent with the idea that many successful biotechnology firms initially license and later switch to self-commercialization. A temporary cooperation switchback may be a route by which startups can eventually realize their ideal strategy of competition. However, this two-stage plan may not be worthwhile if the costs of the temporary, non-ideal strategy outweigh the expected value of eventually achieving the ideal strategy. In the next two sections, we explore prerequisites and risks of a temporary cooperation switchback.

2.3. Bargaining power and temporary cooperation

Given that the purpose of cooperating initially is to learn the skills and capabilities necessary to develop complementary assets, the cooperative agreement must be structured so that the entrepreneur has the opportunity to glean the necessary information. For example, a biotech startup may need to retain rights to participate in the marketing of the product as well as in clinical trials if it is to bring complementary assets in-house eventually. An incumbent may be reluctant, however, to structure a cooperative agreement that could enable a future competitor. If the startup signs a licensing agreement that keeps it "at the bench" without any customer contact or exposure, its temporary cooperation switchback may be thwarted and it may remain permanently in cooperation mode. Thus entrepreneurs seeking to develop complementary assets, including expertise and brand recognition, may need bargaining power in order to negotiate successfully with a licensee for these advantages.

One source of bargaining power is the (perceived) value of the innovation itself. The more valuable the license opportunity appears, the more willing potential licensees will be to involve the entrepreneurial firm in the commercialization process. Independent of the innovation's objective value, therefore, the entrepreneur may be able to increase its perceived value by seeking press coverage and otherwise raising the profile of the technology. Alternatively, a less well-known entrepreneur might try to affiliate itself with prominent partners including highly-visible venture capitalists—possibly accepting a less attractive financial arrangement in exchange for the status tie (Hsu, 2004). Either of these steps may increase the number of potential licensees and thus afford the entrepreneur additional bargaining power.

An entrepreneur who cannot obtain greater bargaining power based on perceived value or prestige may, out of necessity, consider accepting lower short-term revenues in exchange for participation rights, which will at least generate the assets and capability to pursue a switchback strategy later. If unsuccessful at any of these approaches, however, the entrepreneur may have to give up the switchback plan and be satisfied with a permanent cooperative strategy. If cooperation is not attractive in the long-term, the entrepreneur may forego commercializing the innovation entirely.

2.4. Costs and risks of temporary cooperation switchbacks

For a firm that has temporarily cooperated and now wishes to execute the second half of the switchback strategy, the change from cooperation to competition may be organizationally disruptive. Compared to the relatively focused scope of operations needed to maintain cooperative commercialization, entering the market requires greater organizational complexity involving not only new units and functions related to marketing, sales, and distribution, but also the managerial coordination required to make these new units and processes work together with existing organizational elements and with each other. In all of this there is significant potential for difficulty and even failure. Aggarwal and Hsu (2009) find that even slight strategic shifts within a mode of cooperative commercialization are associated with negative valuation consequences in a sample of biotech firms, arguably due to disruption in organizational routines and structure. Success in this transition depends on both well-planned acquisition of complementary assets and operational adaptability.

Even with strong market entry expertise, a firm planning or completing a temporary cooperation switchback must realize, as Arora and Gambardella observe, that "licensing creates competitors" (2009:781). The resulting competition is not limited to the profit-dissipation effect; rather, current downstream partners, who were essential (and carefully nurtured) during the cooperation stage of the strategy, may now become product-market competitors. Particular risks include the loss of revenue as former partners defect and before product-market revenue ramps up. As an example, speech-recognition software developer Nuance Communications expressed concerns when announcing a switch from cooperation to competition. A trade journal article noted that in "a strategy shift which the company admitted carried short-term 'revenue risk,' the company is shifting to more direct sales and to selling products that will put it in competition with some of its partners" (Meisel 2002: 23). In the same article, Nuance CEO Ron Croen acknowledged that the switch "may result in some sales that would otherwise go to partners."

Some of Nuance's difficulties in executing a temporary cooperation switchback arose from trying to switch strategies for a single product. Given that most licensees will demand exclusivity, the sort of channel conflict Nuance experienced may be inevitable for single-product companies unless they achieve a limited or non-exclusive agreement. By comparison, Genentech experienced less friction because it executed the switchback over a series of distinct innovations. Its decision to "make and market" human growth hormone avoided channel conflict because its previous licensing agreement with Eli Lilly addressed only synthetic insulin. In sum, a temporary cooperation strategy is more smoothly realized over a sequence of innovations that do not overlap in terms of cooperation partners or addressable markets.

A final hazard of the temporary cooperation switchback is that the first stage of the strategy exposes the innovator to expropriation risks. Depending on the negotiated scope of the collaboration, interorganizational interaction can be a source of permeable organizational boundaries. Scientific personnel may be exchanged, leading to knowledge flow between alliance partners—whether intended or not (Gomes-Casseres et al., 2006). While there are a variety of contractual and non-contractual mechanisms for limiting knowledge leakage across organizational boundaries, these mechanisms are imperfect. The risk of adverse consequences is heightened given that startup innovators typically are not as well equipped as established industry incumbents for dispute resolution, having fewer resources and less experience with litigation. Both in the shaping of the agreement and in the ongoing management of the collaboration, an innovator entering a temporary cooperation agreement must work to prevent leakage of critically sensitive expertise in order to succeed later in the second stage (i.e., competing).

2.5. Temporary cooperation switchbacks: implications for incumbents

Determining the incumbent's optimal method of engaging with a new venture in the case of a temporary cooperation strategy is nontrivial, especially if the entrepreneur is coy regarding long-term plans to eventually compete in the product market. Even if the founders of a startup are themselves committed to cooperating, professional investors may later install new management with different ideas (Hellmann and Puri, 2002), resulting in an unforeseen switch to self-commercialization. Assessing this potential threat and weighing it against the possible benefits of accessing startup innovation is a significant challenge.

An incumbent who chooses to proceed may optimally insist on exclusivity, either of long duration or wide industry scope, as well as technology advancement grant-back clauses in order to avoid enabling a direct competitor.[8] The incumbent may also avoid co-marketing or other arrangements by which the startup could seek to enable a self-commercialization strategy. Yet some transmission of tacit knowledge may be inevitable, since joint commercialization often involves exchange of personnel and/or allocating personnel from each side to the joint effort. Employee non-compete agreements are difficult to enforce in some states, particularly California, and can motivate employees to move to a non-enforcing state (Marx et al., 2015). Thus if either firm is based in a non-enforcing state, incumbents may be at risk of their technology supplier attempting to hire away personnel.

Fig. 1a shows a decision tree in which the entrepreneur aspires to enter the product market but finds that such a strategy is infeasible due to underdeveloped complementary assets. If such assets are not available via a market transaction (such as in the case of outsourced semiconductor manufacturing or contract-based clinical trial management), two conditions will help enable a temporary cooperation switchback: adequate enterprise bargaining power to structure a cooperative arrangement to enable learning, and contained financial and organizational costs associated with entering the product market.

3. Using a temporary competition switchback to reduce partner uncertainty

A technological innovator may find it difficult to strike a cooperative commercialization agreement because would-be licensees doubt the value of the technology until it has been demonstrated in the market. They may be skeptical, first, as to whether the technology functions as promised, and second, whether customers will find it useful. Both sources of doubt can lead to not only asymmetric uncertainty, where the innovator knows how well the innovation performs but the potential cooperation partner needs to be convinced, but also symmetric uncertainty, wherein neither party is sure of the value.

Asymmetric uncertainty about the value of an innovation can dampen the market for cooperative commercialization, as scholars have long recognized (e.g., Caves et al., 1983). Gallini and Wright (1990) propose to solve the "lemons" problem with contingent licensing contracts of small up-front fees followed by substantial royalties. The effectiveness of such contracts in obviating technical uncertainty may depend on the nature of the complementary assets required to bring the innovation to market. If the licensee is primarily a reseller providing marketing and sales channels, its costs may be largely limited to the license fee. If, however, the complementary assets are more substantial, for example requiring significant elaboration or integration, then an up-front license fee is only a small part of the licensee's costs. Bhattacharya et al. (1998) show that when faced with multiple competing innovations, the would-be licensee can choose to pursue a parallel development path by creating two (or more) versions of the end-user product with each optimized for one of the competing innovations, or to "overdesign" a single end-user product so as to accommodate alternatives. Either path can be worthwhile if the expected value of the innovation is high enough, but the very uncertainty underlying this calculation coupled with the costs of parallel development or overdesigning, may lead the potential licensee to simply delay integrating the new innovation, perhaps while waiting for an industry standard to emerge (see Section 3.1 below).

Symmetric uncertainty, in which neither the innovator nor the potential licensee is sure of the value of the technology, may likewise complicate cooperative commercialization. Symmetric uncertainty may arise either because the most valuable application(s) for a new technology are not immediately obvious, or because quality cannot be reduced to a simple metric such as the speed of a CPU. For "experience goods" in particular, even a technically successful innovation can encounter unpredictable rates of consumer adoption due to factors outside the innovator's control. Consider the case of smartphone operating systems, where end-users may prefer one over another based not only on its inherent quality but also on the availability of third-party applications. As of the end of 2009, Nokia, Google, Microsoft, and Palm all offered smartphone operating systems and had market shares of 46.9%, 7.5%, 8.7%, and 4.6% respectively.[9] Given Nokia's powerful position it might have seemed a natural choice as a partner. However, its market share had declined precipitously over the preceding year. In light of these visibly declining numbers for Nokia's Symbian OS and the roughly equal levels of market share for Android, Windows Mobile, and PalmOS, both OS providers and handset manufacturers faced uncertainty regarding the value of these innovations. The difficult decision of which system to support could not be resolved on the basis either of technical merit or of the market data then available.

As in the case of asymmetric information, it might seem that contingent contracts could facilitate markets for a new technology. In theory, a handset manufacturer could hedge its bets and simply incorporate each of the competing operating systems, following the two paths mentioned above of either parallel development or overdesign as described by Bhattacharya et al. (1998). Although there are cases where this investment proves to be worthwhile, many would-be licensees will decide otherwise. Technology entrepreneurs may hesitate to build a commercialization strategy on incumbents' willingness to in-license multiple unproven technologies just in case the focal entrepreneur's approach eventually proves superior. Uncertainty regarding the value of technology therefore makes it difficult for entrepreneurs to pursue a cooperative strategy.

3.1. Dynamics of partner uncertainty mitigation: Exogenous factors

As in the case of complementary assets, the value of the technology may shift. By this we do not mean that the value of the technology will be better understood or appreciated; rather, that its value to potential partners may change for reasons having nothing to do with the innovator. Demand for the innovator's product may increase or decrease as a result of the growth or disappearance of technologies with which it would be used, or the appearance in the market of a proof-of-concept product may reveal latent demand for products that are similar but more mature, reliable, versatile, etc.

Such exogenous shifts may be particularly prevalent at the resolution of a pre-paradigmatic industry lifecycle stage. As originally formulated by Utterback and Abernathy (1975), technological progress often occurs in two periods. In the first, "pre-paradigmatic" stage, there is no generally accepted design

[8] A longstanding theoretical literature in industrial organization economics analyzes the relationship between technology licensing on the one hand and current and future R&D incentives and product market competition on the other (e.g., Katz and Shapiro 1985; Gallini and Winter, 1985; Choi, 2002).

[9] Gartner Q4 2009 report, http://www.gartner.com/newsroom/id/1543014.

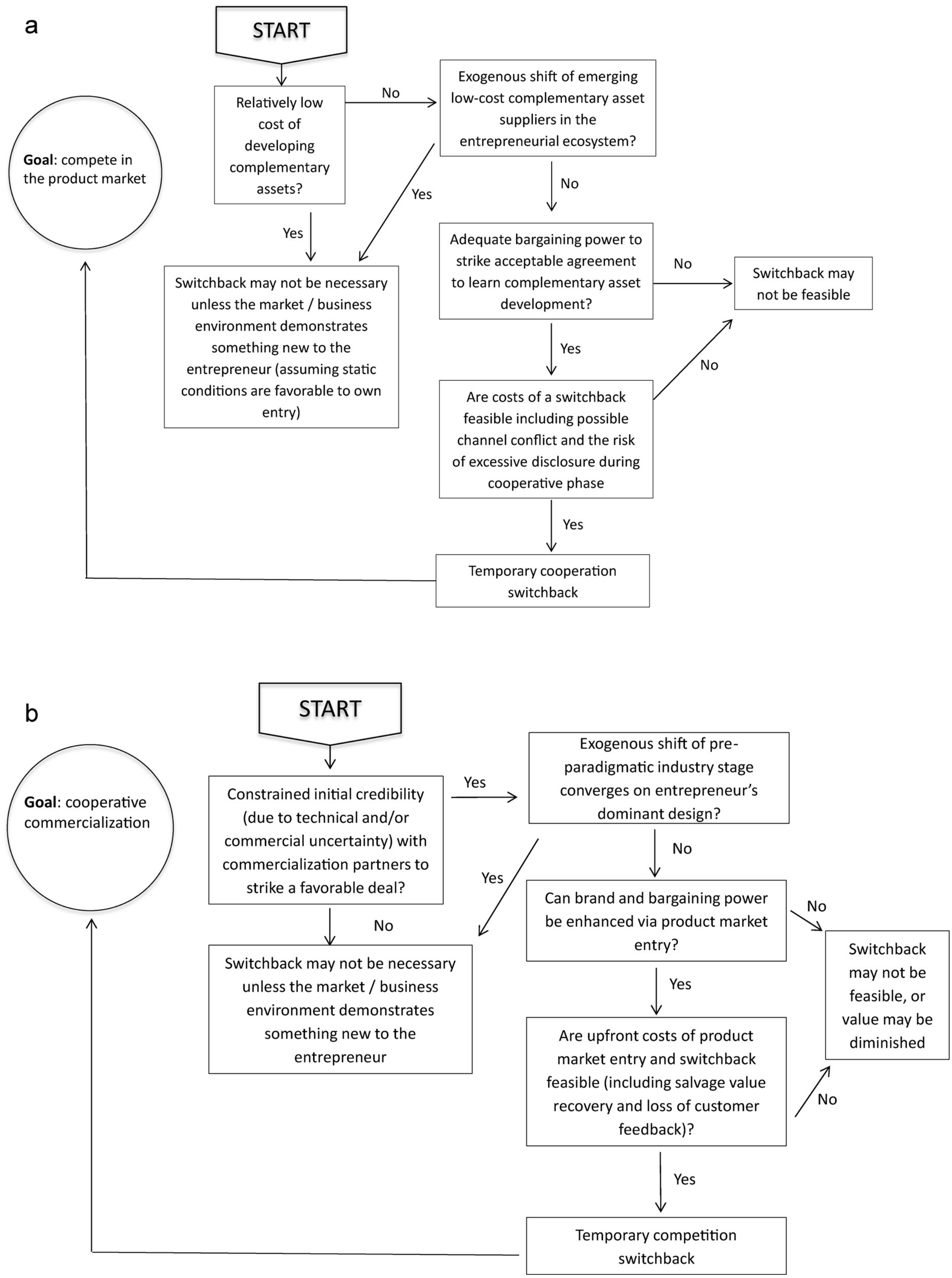

Fig. 1. Temporary cooperation switchback decision tree.

concept for a product category; a variety of approaches may exist in the marketplace, and performance criteria may be ill-defined. In the second, convergence on a dominant design will raise the value of the innovator's focal technology depending on whether it is selected in the market—or, conversely, lower the value of the focal technology if it is not selected. Even if the focal innovation is technically superior, it may not be selected due to political considerations or standards-setting bodies. An entrepreneur may attempt to influence the outcome of these deliberations but seldom has much power.

3.2. The temporary competition switchback as an endogenous resolution to uncertainty

Given the static orientation of prior work on commercialization, the above challenges might suggest that uncertain technologies might never succeed in being licensed. While in rare cases technology uncertainty might be exogenously resolved, more often it is up to the innovator to reduce skepticism on the part of potential partners. While we concur with Arora and Gambardella (2010: 789) observation that “the value of a technology is gradually revealed as time elapses,” little progress will be made if the invention remains ensconced in the research lab. The entrepreneur’s more likely path to eventually securing a cooperative arrangement may, ironically, be found in temporarily entering the product market.

The early history of Research in Motion’s wireless email technology highlights the role of a *temporary competition switchback* in eventually enabling its ideal commercialization strategy of cooperating with partners. Company executives have stated: “from the beginning, RIM’s goal was to build a middleware platform for mobile e-mail that was compatible with multiple devices, applications, networks, and protocols” (Frankel, 2005:37). However, for the first several years of its existence RIM did not license its wireless-email technology because it found that in its current state of development, lucrative licensing partnerships were not available. As co-founder and co-CEO James Balsillie explains: “[There] was really a lack of interest, in the rest of the market, to work with us until we became a standard” (Frankel, 2005:37). Although RIM’s ideal strategy was to cooperate with partners, it came to the decision to directly enter the product market instead (McNish and Silcoff, 2015:39):

“After developing programming tools for users to write applications for Mobitex, RIM wrote software for Mobitex users as well, including a wireless e-mail gateway service called RIMgate. But software did not bring in much revenue; there were not many wireless data customers, and they were not willing to pay much for it. ‘You learn a lot of sobering things’ trying to sell software, Balsillie told a trade publication in 1995. Lazaridis and Balsillie believed RIM would have to start making its own hardware if it was to ever be more than a marginal player. “

The result of this temporary competition strategy was the BlackBerry device, which became ubiquitous during its period of market preeminence. What had been intended as a behind-the-scenes wireless messaging platform became a complete off-the-shelf system marketed directly to the consumer. As Somaya, et al. (2011: 51) recount, “In the early days, the BlackBerry service was unique in that RIM provided everything needed to make it work: the device itself, the software that made it run, the servers that routed e-mail from the wired network, and the airtime that RIM leased from mobile-phone carriers. In other words, RIM adopted a highly integrated organizational model, which enabled the company to retain control over and coordinate all aspects of its service.”

From the theoretical standpoint of the switchback model it is important to note that even if potential partners had not doubted the technical feasibility of wireless email in general, RIM’s predicament was still shaped in part by the fact that the technology was arguably in a pre-paradigmatic technology lifecycle phase in which no solution had been widely adopted. Other companies including Motorola had attempted to sell email-enabled pagers, but no dominant design had emerged. Downstream incumbents had little incentive to gamble on RIM’s standard by investing in the specific hardware designs that would be required in order to build on that standard. Entering the product market generated consumer demand for its Blackberry devices, and Blackberry Enterprise Servers were sought out by corporations eager to host their own secure wireless email. But as Balsillie recounts, the development of an integrated system was a means to get the original innovation sold, rather than an end in itself: “People thought we made money on handsets. It was all services money” (Jackson, 2015).

Likewise, RIM’s shift away from competing directly in the product market took place gradually and deliberately. At first, RIM resold airtime from carriers but in the summer of 2000 reversed course and allowed carriers to sell the device directly to consumers. Leveraging carriers’ sales and distribution channels as well as marketing muscle—complementary assets it did not have at the same scale—is credited with fueling RIM’s dramatic revenue growth in the next few years. Finally, in late 2002 RIM began to cooperate more fundamentally with incumbents by allowing companies like Nokia to integrate its wireless-email technology into its own devices. Said Balsillie, “By offering to license, RIM was able to access the innovative resources of the entire industry. . .leaving [it] able to focus on what it did best: wireless e-mail. We are a middleware. And that is a really useful place to be. A lot of people seem to be agreeing with us by buying our products and partnering with us” (Frankel, 2005:37).

The RIM example shows how temporary competition can enable an innovator to eventually implement its desired cooperative strategy even when the pre-paradigmatic nature of its technology discourages potential partners from engaging.[10] The RIM case primarily deals with the symmetric uncertainty inherent in the pre-paradigmatic phase. However, temporary competition can also be useful given asymmetric information. One such example involves the market for wireless telephone calls, where in the 1980s the time-division multiple access (TDMA) protocol had been widely deployed. TDMA delivered clear cell-phone connections because a single frequency was not simultaneously used for more than a single conversation. Qualcomm then introduced the code-division multiple access (CDMA) protocol, which promised higher network efficiency by handling multiple calls on the same frequency at the same time and managing the interference between them. However, Qualcomm found it difficult to convince handset and base-station manufacturers to sign on because they did not believe CDMA would work. Qualcomm thus decided to enter the product market by building its own CDMA-enabled handsets and base stations and only years later divested these less profitable businesses in favor of higher-margin licensing of CDMA. Said co-founder Andrew Viterbi (2012): “It was essential to produce the infrastructure as well as the handsets. . .to convince the carriers that CDMA was indeed a workable technology. . .there were many skeptics.”[11]

Such challenges are especially common to “disruptive” technologies (Christensen, 1996), so named in part because they surprise incumbents who dismiss them as too radical or as serving unattractive customers and having little value. We suggest that as long as market verification is lacking, innovations with these less appealing characteristics would be better referred to as “potentially disruptive” technologies which, in the context of our discussion of commercialization strategy, may represent unpromising paths and thus be difficult for entrepreneurs to out-license. Marx et al. (2014)

[10] RIM’s recent struggles might cast doubt on the switchback approach. However, perhaps RIM’s mistake was rather that it clung too long to the competitive phase of the strategy—even after its BlackBerry had been outpaced by smartphones from Apple and Google. RIM might have alternatively unbundled its popular BlackBerry Messenger (BBM) and licensed it to other platforms before messaging tools like WhatsApp became popular. In fact Balsillie indicates such an intention: “The BlackBerry Storm had a 100% return rate. . .I knew we couldn’t compete on high-end hardware anymore. I wanted us to open up BBM after the Storm to keep that revenue up” (Jackson, 2015).

[11] As a contrast in the semiconductor context, consider the commercialization strategy of ARM Holdings, the reduced instruction set computing (RISC) architecture firm. ARM has sustained its licensing revenue model since its inception, in part because its chips are meant to be customized by downstream clients and do not face the same level of technical uncertainty and potential information asymmetry associated with the Qualcomm example.

show that entrants in the speech recognition industry who offer potentially-disruptive technologies are more likely to compete in the product market, later switching to cooperation with incumbents. Because potentially disruptive technologies initially perform poorly in comparison to existing solutions and may take radical approaches, incumbents are disinclined to cooperate. Entering the product market can help an entrant facing uncertain assessments of its technology in two primary ways.

First, deploying the productized technology to actual customers can improve the technology itself as feedback flows back to the inventors. This was particularly important in the speech recognition industry as entrants iterated their technologies to the point where they outperformed existing technologies. Innovations which up to that point had been seen as only potentially disruptive (and therefore unattractive licensing candidates) became truly disruptive. Once potential impact is recognized, uncertainty (both symmetric and asymmetric) is reduced. Thus in this industry, temporary entry into the product market facilitated improvements that eventually enabled the ideal cooperative commercialization strategy.

Second, customer adoption combined with positive press can ameliorate uncertainty, whether asymmetric or symmetric. With Qualcomm we see asymmetric uncertainty: the inventors were confident that CDMA would improve bandwidth utilization without sacrificing call quality, but potential OEMs were not convinced until the company manufactured its own handsets and base stations to prove that the call quality was acceptable to the mass market. For RIM, in contrast, the uncertainty regarding customer adoption of wireless email existed on both sides, and so the company was not able to successfully license its wireless-email technology until after the success of its end-consumer BlackBerry product.

3.3. Bargaining power as a motivation for the temporary competition switchback

In discussing uncertainty we have considered the situation in which the innovator is eager to cooperate, but the potential partner is reluctant. We now turn our attention to temporary competition switchbacks resulting from the converse situation: the innovator wishes ideally to cooperate with an incumbent and has identified a potential partner interested in such an arrangement, but the innovator hesitates to take this step out of a fear that it will get the worst of the bargain. In seeking to license an invention which has had no chance to receive market validation, a startup may have little leverage beyond the promise of the technology and therefore may not be well-positioned to successfully negotiate attractive cooperative agreements. Even worse, if the startup is largely unknown, its innovation may become merely an invisible component of the licensee's own offering—a component that the licensee can replace later with a component from another vendor without damage to its sales.

Executing a temporary competition switchback can counteract such difficulties. Prior work shows that the mere threat of self-commercialization can give innovators negotiation leverage (Gans and Stern, 2000), but actually entering the product market and thus gaining experience and reputation may further increase bargaining power. Direct sales serve as evidence of market validation and can additionally give the entrepreneur some financial cushion against which to negotiate. Furthermore, its brand may also then have value to a licensee who would otherwise seek to hide the startup's identity from the customer and render it silently replaceable with an alternative technology. In short, when the entrepreneur lacks bargaining power, a temporary competition switchback may constitute an improvement of the entrepreneur's outside option, or "threat point" vis-a-vis the commercialization partner.

A temporary competition switchback may also help to prevent expropriation of the invention if intellectual property rights have not yet been secured. Even when potential downstream licensees may be eager to cooperate, the risk of expropriation may suggest to the innovator that it is more prudent to wait until rights have been granted; however, the patent examination process can take several years. While an established firm with a large portfolio of innovations can focus elsewhere while waiting for the patent application to be examined, a startup is unlikely to enjoy such flexibility.

Consider FINsix Corporation, an MIT spinoff commercializing high-frequency power converters. FINsix converters enable eliminating the heavy "brick" attached to laptop power cords. Importantly, FINsix did not face substantial uncertainty regarding whether the technology would work. And since a power adapter is an individual customer decision not relying on extensive shared infrastructure, FINsix (unlike Blackberry) did not need to be adopted as a standard. Although CEO Vanessa Green originally considered licensing the technology to laptop manufacturers in order to accelerate distribution, she instead adopted an initial strategy of self-commercialization in hopes that doing so would eventually enable a cooperative strategy feasible, given the concern that the small startup—lacking market reputation, branding, revenue, or other assets—might not be able to negotiate attractive licenses early on (Green, 2013). Moreover, most of FINsix's patents are (as of this writing) still under examination at the USPTO, including its application titled "Very High Frequency Switching Cell-based Power Converter," filed in August 2011. The lack of intellectual property rights may therefore have placed the firm in a less than desirable bargaining position and contributed to the firm's reluctance to engage initially in cooperation.

As a first step in a temporary competition switchback, FINsix announced its plans to manufacture "brickless" laptop power cords and sell them through retail channels. The startup won several awards at the 2014 Consumer Electronics Show, boosting its brand and also facilitating a successful Kickstarter campaign. It is of course too early to declare that the FINsix switchback has been successful; indeed, the firm has not yet entered the second phase of its switchback by re-engaging potential licensing partners. Nonetheless, the case is illustrative of the calculus that may lead an early-stage startup to engage in a temporary competition switchback.

3.4. Costs and risks of temporary competition switchback

As mentioned above, entrepreneurs pursuing a temporary competition switchback may continue to invest to some extent in the initial strategy even after returning to a cooperative path. Alternatively, a startup may make a clean break and pull completely out of direct participation in the market, and in this case will subsequently seek to reduce its own investment in complementary assets. This reduction is not only preferable from a profitability perspective but may be essential: reducing product market investment may, in smaller firms, be the only option for summoning the resources needed to support licensees. For example, when Samsung signed a license to incorporate Vlingo Corporation's underlying technology into its S-Voice offering, it did not actually insist that Vlingo pull its consumer product from the market. Nevertheless, the Samsung deal led to a de facto shutdown of Vlingo's product market efforts simply because all available resources were needed to support Samsung, as noted by Vlingo CTO Mike Phillips: "we cut back on the consumer effort. We didn't want to but in fact that was a hard decision in the company. Making sure to sequester 10–12 people to work on [the] direct-to-consumer [product] would have been great but the pressure meant we needed to divert the resources" (Phillips, 2013).

While divestiture may at first seem simple in that assets such as physical equipment, property, and the like can be disengaged and potentially repurposed or salvaged, shifting away from product market entry can involve more complex issues. First, the more the organization's downstream assets were developed specifically to match the innovator's upstream position, the lower the probable salvage value of the asset under divestiture. Second, without the direct linkage to the end consumer or purchasing agent, future versions of the firm's product or service may be less able to incorporate user feedback into development. Cooperating with partners can of course still yield information about the preferences of the final consumers, but the feedback loop is not as direct and will be filtered through the lens of the licensee.

Another risk of temporary competition is that early public exposure will endanger future licensing potential. One precondition to cooperation is that the entrant has not already disclosed so much information about the innovation in the integrated product that licensing is no longer attractive to potential partners. In "black box" industries such as software or microelectronics this is unlikely to be a concern, but a startup working in the field of consumer products might be concerned that competitors could reverse-engineer the innovation. Anton and Yao (2002) suggest that an important appropriability mechanism in a cooperative commercialization strategy is the ability to selectively disclose innovation details to the would-be partner; this need to avoid disclosure is even greater for entrepreneurs who compete in the product market before attempting to license. Despite their best efforts, the simple act of broad revelation—inherent to some degree in product market entry—could spur subsequent competition. This then becomes an important reversal cost consideration in implementing a switchback strategy.

As an example, consider the case of the Pebble smartwatch. Pebble Technologies raised funding for the watch through the crowdsourcing platform Kickstarter in April 2012, far exceeding its goals by raising $10.2 M in a five-week period from nearly 69,000 backers and garnering considerable media attention. However, some analysts (e.g., Novellino, 2013) believe that the highly visible oversubscription provided valuable market information to possible competitors, and may raise barriers to a subsequent cooperative strategy. Pebble might therefore have benefited from alternative possible funding sources that would have entailed comparatively less public disclosure. The dilemma involved—of a sort commonly faced by entrepreneurs—is that the company's ability to raise a subsequent $15 M venture capital round might not have been possible without the successful crowdfunding campaign.

3.5. *Temporary competition switchbacks: implications for incumbents*

When incumbents seek cooperative arrangements with entrepreneurs who have previously competed in the product market, they are forced to consider not only how to attract and evaluate these potential licensors but also how to structure arrangements to protect themselves. The first step is to identify entrepreneurs who are interested in switching from competing to cooperating. While in many cases these entrepreneurs will present themselves as soon as they have sufficiently resolved technical uncertainty or gained bargaining power, some self-commercializing startups may only become available for partnership if they are actively approached. Startups that have not fully resolved uncertainty or built bargaining power but are growing slowly given the limits of their independent capabilities may be particularly receptive.

Regardless of whether potential switchers arrive voluntarily or need to be recruited, the incumbent needs to position itself as an attractive partner, particularly when the innovation is being offered on an exclusive basis. Priority access to the innovation may involve building absorptive capacity to identify the most promising emerging technologies (Cohen and Levinthal, 1990). This may involve a host of investments including striking alliances, engaging in research consortia in industry or at academic institutions, etc. These investments will not always yield a payoff for a variety of reasons, due to the inherent nature of research and development. Yet developing a reputation for and being in the vanguard of technical development may be important in becoming a preferred partner when an innovator decides to switch to a cooperation strategy. Also, given that entrepreneurs may need to divest product-market assets in order to focus on core technologies they plan to license, the incumbent must have or be willing to acquire such assets. (Presumably, the licensing incumbent's complementary assets will be superior to the entrepreneur's, but scenarios are possible in which the licensee purchases assets from its licensor.)

Having gained the attention of the entrepreneur interested in switching from self-commercialization to cooperation, an incumbent must determine whether the entrepreneur is amenable to a mutually beneficial arrangement given past investments. Entrepreneurs who have previously sold directly to end-customers may be unwilling to completely abandon them; like BlackBerry, they may prefer to maintain some direct customer relationships even if the bulk of revenue is via licensing. Moreover, entrepreneurs who participated in the product market may have long-term distribution contracts they must honor, which could make it difficult for them to exit the product market immediately. The contract may need to carve out exceptions for existing customers or, potentially, for existing markets if the incumbent's primary interest is in markets other than the one(s) served by the entrepreneur.

Fig. 1b summarizes a decision tree leading to a temporary competition switchback. Here, the enterprise goal is to ultimately adopt a cooperative commercialization strategy, but such a strategy is initially infeasible due to technical and/or commercial uncertainty on the part of the partner. There may be exogenous events related to industry lifecycle or adoption by standards-setting bodies that may mitigate such uncertainty, thereby making the switchback strategy less necessary. Absent such events, however, two conditions will help to enable a temporary competition switchback: the firm's ability to enhance its brand and bargaining power in the course of product market entry, and its expected ability to contain the financial and organizational costs of switching to a cooperative commercialization strategy.

4. Boundary conditions for technology commercialization switchback strategies

Having reviewed the costs and benefits of temporary cooperation and temporary competition, we now turn to boundary conditions that may discourage the implementation of a switchback strategy when such a strategy might otherwise seem attractive. These include (1) the nature of rivalry in the market for technology and the product market (2) the munificence of the funding environment, and (3) patent fragmentation for systemic technologies. (While these factors could be added to the flowcharts in Fig. 1a and b, we omit them for the sake of simplicity.) We end with an example of how such boundary conditions can make a switchback strategy less viable.

4.1. *Nature of rivalry in both the market for technology and the product market*

Both types of switchbacks involve cooperative commercialization, either in the first stage (temporary cooperation) or in the second stage (temporary competition). Thus factors influencing the attractiveness of cooperation affect the viability of a switchback strategy, including rivalry both in the market for technology as well as the product market.

Concerning the technology market, cooperative commercialization becomes less attractive when there are many providers of similar technologies. Fosfuri notes that "a larger number of technology suppliers means stronger competition in the market for technology. Licensors have weaker bargaining power vis-a-vis the prospective licensees" (2006: 1146). Similarly, Gambardella and Giarratana (2013) offer empirical evidence that a cooperative strategy may be threatened by an abundance of relatively undifferentiated upstream technology providers. By contrast, the lack of rivalry in the product market can make also cooperative commercialization less attractive, in two ways. First, more entrants in the product market make self-commercialization less attractive, so less product-market rivalry reduces rents from licensing. Second, to the extent that fewer of those product-market entrants represent potential licensees of the focal startup's technology—or, in the extreme case, a monopolist licensee—the absence of rivalry will fail to bid up the license fee.

The implications of higher rivalry in the market for technology and the lack of rivalry in the product market, both of which reduce the rents from licensing, are straightforward for the temporary competition switchback. As the desired end-state becomes less attractive, entrants will only be less eager to incur the costs of temporary self-commercialization.

The effect of decreased returns from licensing—due to increased technology-market rivalry and/or decreased product-market rivalry—on the temporary cooperation switchback is more subtle. On the one hand, a lack of rivalry in the product market makes the end-state more attractive, so entrants for whom a switchback is indicated should be even more willing to incur the costs of temporary cooperation in order to enable their ideal strategy of self-commercialization. On the other hand, if the dynamics of rivalry render licensing extremely unattractive, the increased benefits of eventual product market entry might be outweighed by the increased costs of the first stage. The entrepreneur might justify settling for a financially unattractive agreement in the short term if it has strong financial resources or if complementary assets can be developed quickly; otherwise, the entrepreneur must either find a way to enter the product market directly, or exit. We turn next to the broader role of financial resources in switchbacks.

4.2. Munificence of funding environment

Given that a key driver of a temporary cooperation switchback is lack of resources, startups may instead be able to proceed directly to competition if they are operating in unusually munificent environments for financing by professional investors such as venture capitalists and "angels." Returning to the example of Genentech, had the company possessed enough financial resources early on, it might have been able to acquire a (small) incumbent with a track record of successfully navigating clinical trials. Indeed, to the question of what he might have done differently in building Genentech, Swanson (2000: 126) replied: "I might have looked a little more outside the company we were building to what was going on in other companies. . .looking at how those might be consolidated or incorporated. . .Mergers and acquisitions are always difficult. . .[b]ut I think there's a role for them in terms of the ability to more quickly build up a company." Abundant funds can enable the entrepreneur to skip the period of initial cooperation by acquiring the necessary complementary assets immediately instead of building them over time.

For temporary competition switchbacks, sufficient funding is important because product-market entry by small firms (even on a temporary basis) can be prohibitively expensive. Consider again the case of Qualcomm and the skepticism it faced from cellular equipment manufacturers or telecom carriers regarding its CDMA wireless protocol (Viterbi, 2012). Qualcomm executed a switchback strategy by manufacturing CDMA-based handsets and base stations. However, it was only able to afford this critical commercialization step because it had previously amassed financial resources as a provider of wireless communications for trucking companies.

4.3. Patent fragmentation among systemic innovations

Finally, we consider the impact of patent fragmentation (Ziedonis, 2004; Cockburn et al., 2010) on switchback strategies. By patent fragmentation we refer to the scenario where a systemic (i.e., not standalone) innovation relies for its successful commercialization on various other technologies owned by disparate parties. Generally speaking, highly distributed ownership of relevant technologies will tend to discourage product-market entry unless the innovator can find a work-around alternative to securing all the necessary rights. Since incumbents likely have greater resources as well as pre-existing relationships with patent holders in fragmented industries, they may be in a better position to assemble the rights needed to commercialize the focal invention. It may thus be easier for the entrepreneur to cooperate with an incumbent which owns one of the several needed technologies. For an entrepreneur who prefers a cooperative strategy, patent fragmentation of a system-like product may simply reinforce that choice.

If however the entrepreneur is initially unable to attract partners due to uncertainty regarding the value of the innovation, patent fragmentation may considerably raise the costs and risks of temporary product-market entry with a systemic innovation due to the transaction costs of licensing other components of the system. Thus when patent fragmentation exists, an entrepreneur who might otherwise execute a temporary competition switchback in order to enable a long-term cooperative strategy may be less inclined to enter at all.

4.4. Switchback boundary conditions: the case of Affymetrix

Affymetrix was founded to commercialize microarray technology ("GeneChips"), which helps researchers scan a biological sample for the presence of thousands of genes in parallel (for applications such as screening patients for diseases). GeneChips are manufactured using a photolithography process akin to the method for making semiconductor chips. In addition to producing the chips, the company sells DNA probes and other consumables, manufactures high speed machinery for analyzing samples, and produces a software system for managing microarray data. The company is not engaged in drug discovery or applications in any vertical domain; its business model is instead a biological system-based tool.

At first blush, a temporary cooperation strategy might have seemed appropriate for Affymetrix since one of the key complementary assets is manufacturing GeneChips. The DNA microarray technology Affymetrix uses involves a specialized photolithography process, so Affymetrix might have considered cooperating (at least initially) with a semiconductor firm. Two factors may help explain why Affymetrix pursued an unwavering product market competition strategy rather than a switchback.

First, Affymetrix was in a privileged funding environment. Affymetrix was a spinout of the combinatorial chemistry company Affymax, which was in turn acquired by the pharmaceutical company Glaxo SmithKline. This sponsorship by an incumbent was particularly important at the time Affymetrix was founded, as the venture capital market was just starting to recover from the lean 1988 to 1991 market environment. Having the financial backing of Glaxo allowed Affymetrix to assemble the organizational resources and complementary assets necessary for commercializing their microarray technology (Glaxo still held a significant equity stake in Affymetrix at the time of its IPO in 1996).

Second, Affymetrix proactively mitigated the patent fragmentation associated with their microarray technology by actively patenting across the areas comprising its microarray system (Lenoir and Giannella, 2006). As an early mover in the microarray space (as a reference point, the Human Genome Project commenced in 1990), Affymetrix entered before a dominant design coalesced in the industry. Because of the system-based business model Affymetrix chose to pursue, we speculate that the company was ultimately interested in controlling its product market evolution, which would be easiest through a competitive commercialization strategy. In addition, knowing that a fractured IP landscape in the emergent industry would substantially increase the transaction costs associated with a later shift to competition, the detour to a cooperative commercialization strategy probably would not have been tenable. Furthermore, an initial cooperative strategy might not have enabled its GeneChip branding efforts, which were important in commanding premium pricing for its microarrays given the moderate bargaining power the company commanded in the early 1990s.

5. Discussion and conclusion

We present a dynamic model whereby entrepreneurs unable to execute their ideal technology commercialization strategy start with a non-ideal strategy that enables them to eventually switch back to the ideal strategy. This model encompasses two complementary paths: temporary cooperation and temporary competition. In the former, represented in Fig. 1a, the entrepreneur has the goal of competing in the product market but lacks the complementary assets necessary to do so. In the latter, represented in Fig. 1b, the entrepreneur seeks to enter into a cooperative agreement but lacks either the credibility to attract licensees or the bargaining power to strike an attractive arrangement.

The existing literature on technology commercialization strategy, particularly for entrepreneurs, focuses on the act of setting an initial entry strategy and highlights the role of the commercialization environment in shaping that strategy. In contrast, the switchback model emphasizes the importance of venture execution and implementation in sequencing strategic moves to reach a desired end-state. These strategy dynamics are especially important for startups, as they typically start out resource-poor and therefore arguably need to be more strategic in their entry and scale-up approach than established firms.[12]

Our synthetic framework can be helpful in understanding the dynamics of entrepreneurial strategy formulation in a way that static frameworks might obscure. For example, what explains Genentech's evolution from cooperating with incumbent pharmaceutical firms to competing against them as a fully integrated firm? If examined via the lens of market determinants, for example, one might be inclined to attribute this overall shift merely to idiosyncratic decisions made for a series of innovations that, over time, happened individually to be better suited to self-commercialization than partnering. By comparison, our framework identifies the possibility that broad shifts of this sort may result from a high-level plan, given a desire to eventually enter the product market and a recognition that such a strategy will initially be infeasible. Importantly, the sequencing of the two commercialization strategies is not merely an artifact of waiting for external conditions to change; rather, executing the initial strategy on a temporary basis is necessary to facilitate eventual adoption of the ideal strategy.

While our focus is on extending work on technology commercialization, the notion of sequentially executed commercialization strategies also contributes to the broader literature on strategy. Switching from one strategy to another has primarily been examined in the context of "dynamic capabilities" (Teece et al., 1997; Tripsas, 1997; Eisenhardt and Martin, 2000), where the firm's present strategy becomes no longer viable due to an exogenous change in the environment, such as a technological discontinuity. The switchback model is distinct from the dynamic capabilities approach in two ways. First, a switchback is not necessarily driven by a shift in the environment; rather, switchbacks are motivated by obstacles which can be properties of the firm itself (e.g., lack of reputation or bargaining power). Second, in the dynamic capabilities account, a new strategy emerges because of the failure of the initial strategy due to an environmental shift; in theory, another firm with identical capabilities and resources could enter just after the environmental shift and implement the focal firm's subsequent strategy without having previously implemented the focal firm's initial strategy. By contrast, in a switchback both strategies are planned as a sequence and the later strategy critically depends on having implemented the earlier one.

Switchbacks are also distinct from strategic experimentation (McGrath and MacMillan, 1995), or "pivoting" as it is commonly referred to in the context of startups (Mullins and Komisar, 2009; Ries, 2011). Pivoting posits that the entrepreneur iterates through a series of experiments using A/B testing or other limited implementations of potential approaches to the market. Whether executed opportunistically (Bhide, 2000) or more scientifically (Murray and Tripsas, 2004), the process involves confirming or rejecting a particular strategic approach. If one approach fails, the startup moves on to test another possibility, which may or may not be related to the previous hypothesis. Ideally, the startup would have come up with the eventually-selected strategy at the start and avoided wasting the time spent evaluating rejected hypotheses. A switchback, however, is not motivated by the failure of any earlier strategy; rather, the subsequent strategy depends on the success of the initial one.

This paper represents a first step in exploring dynamic commercialization strategies, and considerable future work remains. In particular, empirical work is needed to establish whether and when the adoption of a switchback strategy leads to higher returns. Marx et al. (2014) show that entrants with "disruptive" technologies are more likely to adopt temporary competition switchbacks, but they do not examine the implications for financial performance. (Of course, causality may be difficult to pin down given that switchback adoption is unlikely to occur randomly.) Also of interest is whether firms use switchback strategies outside the realm of technology commercialization: might we see switchbacks between vertical integration and specializing within the value chain in consumer goods or services? Further data collection can enable a robust debate regarding the strategic switchback model's applicability over a range of industries and business scenarios.

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[12] Switchbacks may also have application to established firms, in particular for entry into unfamiliar markets where the existing resources and reputation of the firm afford little advantage. However, the larger space of strategic possibilities for a large firm may render switchbacks more difficult to identify as opposed to diversification, product-line extension, international expansion, or other strategic choices available to a larger firm.

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