

THE MODERATING EFFECTS OF TECHNOLOGICAL CAPABILITIES ON THE MARKET PIONEERING - FIRM SURVIVAL RELATIONSHIP

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ABSTRACT

We investigate firm survival in a rapidly evolving industry where new technological sub-fields and market segments emerge frequently. We re-examine first mover advantage (FMA) through a dynamic, evolutionary lens while taking account of technological aspects of the product. Our findings demonstrate the importance of considering technological performance in FMA studies.

INTRODUCTION

While first-mover advantage (FMA) has garnered substantial traction, conflicting empirical findings have raised fundamental questions regarding its validity. In revisiting FMA, our marked departure from existing literature is on two fronts. First, we incorporate a fundamental aspect of product-markets that the pioneering literature has ignored, namely the technological aspect of the product itself. Second, we question the relevance of the extant static, legacy-based notion of “first-mover advantage” in industries that undergo constant and rapid change, and focus instead on a more dynamic, evolutionary version.

The first mover advantage research in strategic management has been studied separately from issues related to technological performance. This is surprising, since a parallel body of literature in operations management and marketing suggests that firms face a fundamental trade-off between time-to-market and product performance (Hatch & Macher, 2002). This raises the intriguing possibility that models of FMA that do not incorporate product performance, such as embodied technological capabilities, may at best be incomplete, and at worst, be mis-specified. Further, extant treatment of FMA indicates a belief that firms have only one chance to pioneer markets in any given industry, and that those who do may be able to sustain their pioneering

advantages over time even as the industry undergoes fundamental metamorphosis. By adopting a dynamic perspective of FMA, we address this shortcoming of existing studies.

We test our hypotheses in the empirical setting of the disk drive industry during 1977-1997. This industry is an ideal setting given that it was characterized by a series of architectural innovations that resulted in the creation of entirely new product markets (Christensen, 1993). Specifically, we investigate the conditioning effect of technological capabilities on the relationship between the ability of a firm to create, and respond to new market opportunities and their likelihood of survival. Building on the idea that a firm requires *both* technology and market creating capabilities to profit from innovation (Teece, 1986; Griffin & Hauser, 1996), we show that successful pioneering involves not only complex first mover skills, or the ability to conceptualize and execute a set of integrated marketing decisions that meet the value requirements of new segments of customers before competitors, but also the contemporaneous presence of technological capabilities.

Our study makes several important contributions. First, we address chronic concerns that have plagued the FMA (and the related order of entry) literature. We advance the notion of timing of entry needs to consider the multiple pioneering opportunities that are available to a firm as an industry evolves, and when more markets are created. Further, we show that the presence of contemporaneous technological capabilities is an important contingent factor in determining the advantage or disadvantage associated with market pioneering. Second, we contribute to the new product development literature that examines potential trade-offs between timing of entry and product quality. While it may seem intuitive that in fast paced industries there are benefits to moving early even though product specifications have not been perfected and are lagging behind, our research provides a cautionary note. Trading off product performance in favor of being early to market may hurt a firm even in industries with short product-cycles, if the product does not satisfy certain minimum levels of performance as required by early markets. Specifically, if there is a choice to be made between being fast or good, firms that delay entry to ensure superiority on the technological dimension are advantaged over firms that enter early with lower than acceptable levels of technological performance in their products. Third, in the corporate entrepreneurship literature, much has been made regarding incumbent inertia and the discussion of how entrants may possess more flexibility than incumbent firms. We show that firms that undertake renewal as the market changes, whether early or late are better off than firms that do not adapt. In the context of the strategic entrepreneurship and dynamic capabilities literature, we find a synergistic relationship between technological capabilities and strategic decisions related to entrepreneurial entry in new markets. We find that performance advantages are highest for firms that are able to invest in strategic renewal along both dimensions, as opposed to one alone.

THEORETICAL FRAMEWORK AND HYPOTHESES

Even though industry and product life cycles are typically characterized by smooth evolutionary curves, such portrayals often mask multiple occurrences of technological shifts. The emergence of new technical sub-fields or new product-markets creates a fresh set of entrepreneurial opportunities. Such changes present both incumbents and new entrants new opportunities to pioneer. In such contexts, we theorize that considering the sustainability of any advantage that accrues to a firm by virtue of being a pioneer in the very first market segment of the industry holds little meaning, especially since emerging market segments tend to displace the earlier ones over time. While recasting market pioneering in this dynamic view, we draw on

insights from the first mover advantage literature that highlights the offsetting benefits and costs of being early to market. We contend that in the context of pioneering new markets within the same industry, the benefits outweigh the potential disadvantages; market pioneering and improving technological capabilities are re-enforcing activities. Particularly in industries where new markets represent opportunities to differentiate a firm's product offerings from an increasingly standardized older generation of products, market pioneering offers firms the ability to escape intense price competition and rapid commoditization. In such a situation, the initial monopoly window is likely to provide important first mover advantages not only due to the reputation effect of offering new products, but also due to the temporary price umbrella afforded by low competition. Therefore,

H1: Pioneering new markets increases a firm's likelihood of survival

Once a new market has emerged, incumbents that did not engage in the pioneering act are faced with a choice of whether to expand into the new segment or not. The choice may not be a trivial one; Christensen (1997) documents the dilemma faced by technologically savvy firms who pay close attention to their current customer needs, but in the process fail because of missed opportunities to embrace disruptive changes in the technology and the introduction of new customer segments. However, to the extent that firms follow a "wait and see" strategy but decide to enter the new market once it has been established by a pioneering firm, responding to the emerging market implies that they may be able to share in the gains of a growing market segment, while having offset some of the risks of being first,. Accordingly, we have:

H2: Responding to new markets increases a firm's likelihood of survival.

Thus far, our focus has been on how timing of entry into a new product market influences firm survival. Another crucial determinant of survival is the firm's proprietary technical knowledge and innovative capability (Schoonhoven, Eisenhardt, & Lyman, 1990). Since technological knowledge is typically tacit, developed over time, and carried within the knowledge structures of specialist personnel, it is likely to constitute a source of competitive advantage since it enables a firm to differentiate its product from that of its competitors. In industries that experience rapid technological progress, technological progress leads to a situation similar to an arms race, where the true measure of capabilities needs to be in a relative, rather than absolute setting. Although firms may enhance their technological capabilities relative to their prior levels briskly in absolute terms, what matters to competing organizations are their relative positions in the technology race. Thus, while a firm's technological capability is the product of both scientific breakthroughs and complex learning processes within the organization, the performance consequences of such capabilities need to be related to the ability of a firm to establish a position of superiority relative to the technology frontier in the industry at any point of time. Therefore, we hypothesize that

H3: Technological capability is positively related to a firm's likelihood of survival.

To profit from innovation, however, a firm requires *both* technology and market creating capabilities (Griffin & Hauser, 1996). Since marketing capabilities and technological know-how feed into one another, they are co-specialized assets in that the value of one is dependent on the level of the other. Accordingly, it has been suggested that firms maximize the benefits from its product development process when both capabilities are present (Teece, 1986; Cohen & Levinthal, 1990). While firms need a minimum level of technological capability in order to be able to create valuable market opportunities (Bierly & Chakrabarti, 1996; Cohen & Levinthal, 1990), they simultaneously need marketing know-how to appropriate the potential stream of economic rents from their inventions (Dierickx & Cool, 1989; Teece, 1988). The complementary

nature of these capabilities, therefore, creates a valuable synergy that increases a firm's effectiveness and efficiency. Accordingly,

H4: Technological capabilities moderate the relationship between (a) pioneering and (b) market responding and a firm's likelihood of survival such that at high levels of technological capabilities, the relationship between (a) pioneering and (b) market responding and a firm's likelihood of survival is strengthened.

Finally, we examine the relative value of technological capabilities for pioneers when compared to responders. As technology evolves, so does the nature of demand. As the diffusion literature suggests, early adopters who meet the earliest versions of the products that are launched into the market by the pioneering firms, are typically moved by the consideration of functionality on a technological dimension, whereas follower demands can be met with niche-based products that meet "whole product" requirements even though they may rate lower on technology performance relative to the cutting edge versions available in the market (Moore, 1991). Further, the co-evolutionary process of technology races leads to segmentation *within* a product market, where more advanced and less advanced technologies each appeal to different customers, require different inputs, and often compete on a different basis (Podolny & Stuart, 1995). Accordingly, we argue that to be successful in establishing a new market, the positional advantage as a technological leader is likely to be even more valuable than it would for a later entrant who may compete on some other performance parameter that cater to either a niche market, or a category of consumers who enter the market at a later stage of the diffusion curve and to whom cutting edge functional performance is less relevant than say customer service, or some other market based criteria in the hierarchy of needs (Christensen & Bower, 1996).

Therefore, we propose that

H5: The synergistic effect of technological capabilities on a firm's likelihood of survival will be stronger for pioneers than it will be for responders.

DATA & METHODOLOGY

Empirical Context

We test the hypotheses in our study using data from the rigid disk drive industry from 1977-1997. Disk drives are magnetic information storage devices used with computers. Architectural innovations led to five new diameters within the 20-year period considered in our study. In addition to the introduction of new markets, the evolution of the disk drive industry is also characterized by rapid technological change due to numerous incremental and modular innovations, resulting in technology S-curves within each successive market. Thus, both due to the multiple new markets that were created and to the rapid change on a key dimension of technological performance, the disk drive industry represents an ideal empirical context for our study.

Our data contains the entire census of firms in the industry during the 1977-1997 period; since every productive firm, regardless of size, is included for their span of existence in the market, our sample does not suffer from survival bias for the period under analysis.

Variables in Study

Firm Survival: The dependent variable in our study, firm survival was computed as a dummy variable that takes a value of one if a firm survived to the following year (with acquisitions being treated as censored observations), and is zero otherwise

Timing of Entry into Market Measures: *Pioneering Markets and Responding to Markets:* The five architectural innovations of new diameter introductions represented the

creation of new markets and are the basis of our market pioneering and market responding measures. Firms that enter in the first year of the new market are identified as pioneers in that market, while existing firms that eventually enter the market are identified as market responders.

Technological Capabilities: We use the Agarwal et al. (2004) measure for a firm's technological capabilities. This measure is based on the average of the firm's diameter-specific relative technological position across all the diameters it produced in a particular year.

Control Variables: Firm level control variables include measures for firm age, size and country of origin. Industry level controls include industry sales, growth, highest areal density, number of firms, and number of new entrants. Finally, year dummies for entry year of the firm were included to controls for differences in founding conditions.

Estimation Methodology

We use hazard rate methodology to test our hypotheses which relates to the probability of a firm surviving in a given year. We used a multiple spells formulation with a complementary log-log specification, and controlled for firm level unobserved heterogeneity by using a random effects specification.

RESULTS

Due to space limitations, we omit the Tables of results, and instead report a summary. The main effect of pioneering markets is *not* significant, indicating that H1 is not supported. Responding to markets has a positive and significant effect on survival, thus, H2 is supported. Further, higher levels of technological capabilities enhance the probability of survival this supporting H3. In our interaction model between pioneering and technological capability, we find that (a) the simple effect of pioneering is negative and significant, indicating that for lower levels of technological capabilities, entering markets early reduces the probability of survival relative to non-pioneering or non-responding firms, while (b) the positive and significant interaction term between pioneering and technological capabilities indicates that pioneering firms that also possess higher levels of technological capabilities have a higher likelihood to survival. In our interaction model between market responders and technological performance, we find that (a) the simple effect of responding to markets is not significant but the interaction effect is positive and significant.. The results indicate that while responding to markets does not help or hurt firms that have zero to low levels of technological capabilities, it is beneficial for firms that have higher levels of technological capabilities. Taken together, the coefficients of the interaction terms of technological capabilities and the pioneering/responding variables provide support for H4. Notably, the interaction coefficient between technological capabilities with pioneering is greater in magnitude and stronger in significance than the interaction coefficient between technological capabilities with responding to markets (t-statistic for test of differences = 2.25, $p < 0.05$). This indicates that the moderating effect of technological capabilities for firms that pioneer markets is stronger than for firms that respond to markets, thereby supporting H5.

DISCUSSION AND CONCLUSION

In high-technology dynamic industries, the process of strategic renewal requires rapid commercialization of technology through market pioneering activities. We examine the interplay between pioneering advantage and technological capabilities in a context where firms have multiple opportunities to be first movers. Specifically, we study how market pioneering capabilities affect likelihood of survival (H1); how market responders, or incumbents who missed the chance to pioneer but subsequently reacted and entered the emerging markets,

influenced their survival chances (H2); how firm ability to stay close to the technological frontier impacts survival (H3); and the relationship between technological capabilities and entry timing on survival (H4 and H5).

We find that when accompanied by lower levels of technological capabilities, early entry into new markets hurts vis-à-vis firms that enter late, or even firms that do not enter the emerging market at all. Pioneering therefore does not appear to be a virtue for poor technological performers. However, the best results are experienced by the firm that is both fast and technologically capable. For higher levels of technological capabilities, we find not only does pioneering increase a firm's likelihood of survival compared to responding firms, there exists a positive synergistic relationship with technological capabilities, since the benefits of pioneering for survival increase disproportionately with unit increases in technological capabilities.

From a theoretical perspective, we find evidence that the relationship between technology and market capabilities is more complex than hitherto envisaged. While we do find evidence that they are co-specialized and that the beneficial effects of one increase in the presence of the other, our results also show the hazards of developing market pioneering capabilities without a concomitant investment in technological capabilities. Our work also adds to the emerging dialog on strategic renewal through corporate entrepreneurship. As 'dynamic capabilities' gains center-stage in management research, it becomes apparent that firms need to invest in sustained regeneration and strategic renewal. While there are no arguments regarding the importance of strategic renewal, research has long debated the inherent conflicts and difficulties therein. Scholars have advanced the importance of organizational ambidexterity, or the simultaneous need for businesses to be aligned and efficient in today's markets even as they engage in longer-term focused entrepreneurial activities that may require them to destroy and cannibalize their current operations. Our research provides empirical evidence of what may be termed as *capability-based ambidexterity* or that which arises from an organization's portfolio of strategic capabilities. Our contribution here relates to our focus on two capabilities that are core to strategic entrepreneurship in high-technology markets characterized by frequent disruptive innovations: the ability to pioneer or respond to emerging market segments, along with the ability to stay on top of the technology curve.

REFERENCES AVAILABLE FROM THE AUTHORS

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