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# A framework and model for absorptive capacity in a dynamic multi-firm environment

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ABSTRACT

Researchers have made significant strides toward understanding how absorptive capacity influences firm performance. However, most of these developments have been theoretical in nature, and have been conducted in single-firm contexts. Our study answers prior calls for more empirical and mathematical treatments in multi-firm contexts that nurture a vibrant and balanced research stream. Our study adopts a mathematical modeling approach to investigate the influence of absorptive capacity on the performance of a firm in a dynamic multi-firm context. We develop a theoretical framework that drives the modeling exercise to gain insights on two research questions: (1) Relative to the dominant player in the industry, what level of ACap should a firm be endowed with to increase its long-term value in a dynamic environment? (2) Is there a threshold *value* of ACap endowment that makes it more likely for a firm to challenge the dominant player in the industry? We provide an analytical result, and further, we conduct a numerical study with two firms and seven periods. Our results suggest that there *are* ACap hurdle rates that a firm must meet to survive and grow. In addition, our model suggests that smaller firms in an industry may do well to strive for unique combinations of ACap, prior knowledge, and initial firm value, to compete successfully against the dominant player in the industry. Our work serves to open new avenues for future research that addresses the influence of ACap endowments on firm performance in dynamic multi-firm environments.



## 1. Introduction

Entrepreneurship research suggests that it is possible for firms to sustain high growth (e.g., Hambrick and Crozier, 1986; Baum and Bird, 2009) and rapidly challenge the dominant player in the industry. In addition, popular press publications like Inc™, Forbes™, BusinessWeek™, and Fortune™ periodically highlight small- and medium-sized enterprises that have accomplished this feat. But, why are these firms the exceptions, rather than the rule? Are there certain factors that stack the odds in favor of the firm that attains the lofty target of surpassing the dominant player in the industry?

Strategic management researchers, and practitioners alike, agree that the secret to success may lie in the firm's take-off "velocity," and its ability to dynamically adapt (change) to the constantly changing environments. The popular press is replete with evidence of business executives who are constantly looking for ways to nimbly affect organizational change in increasingly dynamic environments. Not surprisingly, an understanding of how firms position themselves, and manage change, has become a research mantras today. Researchers have redoubled their efforts to search for conceptual frameworks that help managers achieve organizational change, sustain competitive advantage, and improve long-term firm performance. For example, research on competitive dynamics (Chen and Miller, 2012; Ndofor et al., 2011; Chen, 1996), dynamic capabilities (Teece et al., 1997; Zott, 2003; Helfat and Winter, 2011; Peteraf et al., 2013), first mover advantage (Lieberman and Montgomery, 1988), ambidexterity (Tushman and O'Reilly, 1996; Raisch and Birkinshaw, 2008; Lavie et al., 2010), and entrepreneurial opportunity and survival (Sarasvathy et al., 2010; Bradley et al., 2010) are representative of significant research effort that has focused on how organizations change.

The key question seems to be: How does a firm adjust its capabilities to perform competitively in an uncertain and changing environment? Cohen and Levinthal (1990) argue that firms do this, by continuously acquiring and exploiting new knowledge. They labeled the phenomenon the Absorptive Capacity (ACap) of the firm. Since the publication of this seminal piece, researchers have made significant strides toward understanding how the ACap construct can be used to explain firm performance and long-term value. However, our review of the literature on absorptive capacity uncovered two

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surprising facts. First, we found that recent developments have been primarily theoretical in nature, and researchers (e.g., Lane et al., 2006) suggest that other approaches are necessary to triangulate and build a cohesive and rigorous theoretical foundation. For example, our survey of mathematical treatments of the ACap construct suggests that only a few such treatments can be found in the extant literature (e.g., Jansen et al., 2005; Tu et al., 2006).

Second, we found that the primary focus of prior ACap research, barring a few exceptions (e.g., Mowery and Oxley, 1995; Liu and White, 1997, Bagchi et al., 2014), has been at the firm level. When the unit of analysis is the firm, the impact of the rich and dynamic characteristics of the environment tends to be discounted, or even ignored. Hence, there have been calls by Van den Bosch et al. (1999) and by Gilbert et al. (2008) for more research that examines the influence of ACap on firm performance in dynamic multi-firm environments.

Our study adopts a mathematical modeling approach to answer, in some part, the scholarly calls for research on the relationship between ACap and firm performance in dynamic multi-firm environments. To the best of our knowledge no research has used a mathematical modeling approach to undertake such an exercise. In fact, we could find no research frameworks that articulate the influence of ACap on the cumulative value of firms in a dynamic multi-firm environment.

### 1.1. Research objectives

This study begins with the development of a generalized framework for investigating the influence of ACap on firm performance. We proposed to use the framework to explore the influence of ACap on the stock and flow of knowledge across firms in a dynamic multi-firm environment, and arrive at insights on its influence on the long-term performance of the firm (measured as the value of the firm after 'n' periods). To limit the scope of our study and to make it manageable, we chose to focus on two useful research questions that arose from our review of the entrepreneurship, strategic management, and organizational change literatures:

1. In a dynamic multi-firm environment, what level of ACap should a firm be endowed with to increase its long-term value relative to the dominant player in the industry?
2. In a dynamic multi-firm environment, are there unique initial firm configurations that make it more likely for a firm to challenge the dominant player in the industry?

*The Approach:* We operationalize our framework by developing a mathematical model, and support the functional forms assumed in the model via extant literature. Mathematical modeling is particularly suitable for this type of knowledge diffusion research because of its ability to provide the ability to investigate a dynamic phenomenon whose outcomes are nonobvious, and not predetermined (Kiesling et al., 2012; Nan et al., 2014). Another advantage is that mathematical modeling, minimizes context- and population-specific biases, allowing for more generalizable conclusions. In addition, it is well suited to problems that call for inductive reasoning. Building on the work of Abrahamson and Rosenkoph (1993), we note that some of these characteristics are relevant to our study that is concerned with the diffusion/absorption of knowledge in a multi-firm context, where the influence of the dynamic interactions of dis-similar firms on firm performance is nonobvious. A mathematical modeling approach allows us to observe results, and speculate on how the dynamic processes present in the multi-firm context generated the results. This, in turn provides the insights needed to answer to our research questions.

### 1.2. The context

We consider a dynamic multi-firm environment in which each firm is interested in increasing its long-term value, driven by endowments of ACap across multiple periods. We consider important antecedents of ACap for each firm, implicit interaction between firms via a common knowledge pool, and appropriate diffusion and modulation mechanisms that affect the stated antecedents and the common knowledge pool from one period to the next.

We provide an analytical result for sensitivity of ACap to the cumulative value of the firm. To gain further insight into the workings of our model, and given the difficulty of structural results due to the inherent complexity of the model, we conduct a numerical study of a stylized setting with two firms operating over seven periods. The firms are dissimilar in size (modeled as firm cumulative value) in Period-1. The larger firm represents the "dominant firm" in the industry and, as such, reflects "norms" in that industry. The other firm represents the typical "smaller" firm in the industry, and is modeled as having lower initial cumulative value than the dominant firm. We then use existing research to model/parameterize the related variables/characteristics for each firm.

### 1.3. Potential contributions

We contribute to the literature in three ways. First, we develop a framework and mathematical model for ACap in a dynamic multi-firm environment. Second, we demonstrate the existence of an ACap hurdle-rate that a firm needs to exceed in order to increase its long-term value relative to its competitors. Third, we establish the requirements for a firm to aspire for and attain dominant-player status in an industry. Finally, we demonstrate that a firm needs to achieve a "critical mass" to supersede the dominant player in the industry.

This paper is organized as follows. In the next section, we review the ACap literature including prior work that has attempted to mathematically model the construct. We identify gaps in the literature with respect to modeling ACap endowment, multi-firm and multi-period aspects, and temporal characteristics of critical antecedents of ACap. In the section thereafter, we develop our framework while carefully outlining our assumptions. Our framework drives the mathematical modeling that follows. We conduct several numerical experiments and validate our results against observations found in the literature, and in practice. In the final section, we conclude with a summary of our findings, address limitations, and propose future research directions.

## 2. Literature review

### 2.1. Competitive behavior and dynamic capabilities of firms

Classical theory on the competitive behavior of firms suggests that rents accrue from the firm's ability to maintain a competitive advantage in the marketplace, and that firms must work hard to sustain this advantage in a changing environment. Gradually, theoretical developments aimed at explaining firm behavior were offered to frame the problem in the context of "alignment" – the fit between the firm and its environment. Beginning with work by Andrews (1971), researchers have addressed the "fit" issue extensively. However, much of this work models the process as a deterministic set of sequential activities and events that lead to a new state of equilibrium.

Work by Van den Bosch et al. (1999) recognizes the dynamic nature of fit, and has highlighted the lack of research that incorporates these dynamic aspects. As the development and validation of fit routines progressed, research rooted in real option