The Effects of Firm Experience and Relational Resources on Firm Product Development Capabilities

David Bengt Thornblad

Dissertation submitted to the faculty of the Virginia Polytechnic Institute and State University in partial fulfillment of the requirements for the degree of

Doctor of Philosophy
In
Business, Management

Devi R. Gnyawali (Chair)
Kevin D. Carlson
Steve Gove
Marc T. Junkunc

May 8, 2014
Blacksburg, Virginia

Keywords: Experience, Relational Resources, Product Development, Effectiveness, Efficiency

The Effects of Firm Experience and Relational Resources on Firm Product Development Capabilities

David Bengt Thornblad

ABSTRACT

Given that the focus of strategic management research is understanding the determinants of firm performance, and that product development capabilities have been shown to influence firm performance, the research question this dissertation attempts to answer is: what factors influence a firm's product development capabilities? Building on the resource based view and evolutionary theory, this dissertation proposes that firms leverage knowledge generating resources to modify or develop their routines. Firm level routines are theorized to influence the capabilities of the firm. This dissertation focuses on two firm-level product development capabilities: effectiveness and efficiency. Effectiveness refers to a firm's ability to develop desirable products and efficiency refers to the firm's ability to develop those products quickly.

The knowledge generating resources this dissertation examines is the firm's prior experience in product development and the firm's relational resources pertinent to product development. Specifically, this dissertation develops theory on four types of experience: market niche, component technology, platform technology, and general product development. Additionally, theory is developed regarding the effects of platform relational resources, as well as the breadth and depth of co-developers a firm utilizes in the development of their products.

Using the videogame development industry as the empirical context, few hypothesized relationships are statistically or substantively significant. Prior experience with component technologies lowered the effectiveness of a firm' product development capabilities, but were found to increase efficiency. In addition, older firms tended to create more desirable products

despite controlling for the four types of experience which may suggest that the age of the firm contributes something to the firm's ability to create desirable products beyond specific types of experience.

This dissertation makes contributions to the theory on how capabilities are developed and enhanced by introducing mechanisms regarding how firms can leverage knowledge generating resources to improve their capabilities. More specifically, this dissertation provides contributes to the product development literature as well as the literatures on how experience and relational resources influence a firm's product development capabilities.

ACKNOWLEDGEMENTS

I do not believe I would have completed my dissertation and this Ph.D. program without the support of several people. First, I would like to acknowledge my family who has consistently been there to encourage me throughout these past five years. Without your support, I do not know if I would have succeeded in obtaining my Ph.D.

Academically I would like to thank my committee for their insights and support of my research. Each of you contributed uniquely to my dissertation and I forever grateful. Specifically, I would like to thank my advisor, Dr. Devi Gnyawali, for his insights, time, and support during my dissertation. I am very appreciative of the fact that he agreed to chair my dissertation despite not having worked with me before. Further, he expended a lot of time helping me to refine my theory and develop my theory building skills throughout the dissertation process. Thank you for all you did to help me.

I would also like to acknowledge Dr. Kevin Carlson who was my advisor my first three years of my program and remained on my committee. Thank you for all of the time you committed to my development, particularly my summer research project. I recognize that the summer research project was out of your realm of expertise but you were willing to learn new literatures to help me succeed. For this and much more, I am grateful.

When I first entered the program Dr. Gove became an important mentor to me. He helped me to understand important aspects of academia. Through his guidance I have gained a boarder understanding of the profession I have chosen, as well as important research skills. You always had your door open to me which meant a lot, and I wish you the best.

I have made several friends at Virginia Tech who have helped me through the rough times. Cathy Fleming, who I met in my first week at Virginia Tech, is one of my closest friends. I will always remember how we struggled to make it to day thirty-eight of the semester and the good times we shared downtown. Hanko Zeitzmann and Gretchen Schaupp both taught me how to navigate the department and the program, along with many laughs, for which I am indebted. Further, to all of the other Ph.D. students that I shared my time with, you all had an impact on me and your encouragement and laughter helped me more than you may know.

Finally, I want to thank Anastasia Cortez for copyediting my paper, as well as Mario Cortez III for his help in collecting my data.

Table of Contents

List of Figures

List of Tables

1.0 INTRODUCTION

1.1 Introduction

A primary focus of the field of strategic management is understanding the sources of a firm's competitive advantage (Penrose, 1959; Wernerfelt, 1984; Barney, 1991). Firm capabilities are considered to be a key source of a firm's competitive advantage (Eggers & Kaplan, 2013). Firm capabilities refer to a firm's ability to perform a desired activity or task successfully (Helfat et al., 2007). A firm's product development capabilities have been shown to influence a firm's performance (Kroll et al., 1999; Tatikonda & Montoya-Weiss, 2001; Carpenter & Nakamoto, 1989; Lieberman & Montgomery, 1988; Kerin et al., 1992; Bowman & Gatignon, 1996; Robinson, 1988; Urban et al., 1986). Understanding the antecedents to firm product development capabilities would better our ability to understand an important determinant of firm performance. Therefore, the broad research question this dissertation attempts to answer is what factors influence a firm's product development capabilities?

Recent work has emphasized the critical role of a firm's *prior experience* in the development of a firm's capabilities (Egger & Kaplan, 2013). Firm experience is argued to be a source of *routines,* and routines are the foundation of a firm's capabilities (Egger & Kaplan, 2013; Nelson & Winter, 1982). In addition, it has been shown that different types of experience influence the development of capabilities differently (Eggers, 2012; Nerkar & Roberts, 2004). Therefore, the types of experience a firm has may play an important part in determining a firm's product development capabilities. Correspondingly, this dissertation examines different types of experience and how they influence the development of a firm's product development capabilities.

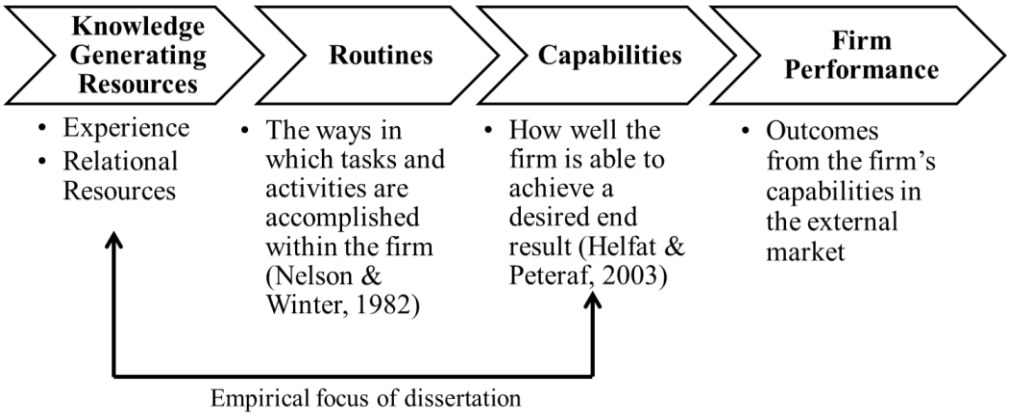
Experience, however, is an internal resource for a firm and external resources may also play critical roles in developing a firm's product development capabilities. The relational view emphasizes that firms may be able to enhance their capabilities and generate rents by partnering and establishing relationships with other firms (Dyer & Singh, 1998; Lavie, 2006). Therefore this dissertation examines how relational resources, as an external resource, can influence a firm's product development capabilities. Given the important role that product development capabilities play with regard to firm performance, and the role of experience and relational resources as key resources a firm can utilize to enhance its product development capabilities (Dyer & Singh, 1998; Eggers, 2012; Eggers & Kaplan, 2013), this dissertation is motivated by the three important theoretical questions listed below.

1. How do different types of product development experience influence a firm's product development capabilities?
2. How do relational resources pertinent to product development influence a firm's product development capabilities?
3. How do experience and relational resources jointly interact to influence a firm's product development capabilities?

The basic model guiding this dissertation is depicted below in Figure 1.1 and is grounded in both the Resource Based View (Barney, 1991; Wernerfelt, 1984) as well as Evolutionary Theory (Nelson & Winter, 1982). First, I introduce the concept of knowledge generating resources which include, but are not limited to, experience and relational resources. I theorize that knowledge provided by these resources would help to modify and improve the firm's routines, defined as the way in which tasks and activities are accomplished within the firm (Nelson & Winter, 1982). In turn, routines influence a firm's capabilities: how well a firm is able

to achieve "a particular end result" (Helfat & Peteraf, 2003, p.999). The capabilities of the firm influence the firm's competitive position in the external marketplace.

Figure 1.1: Overview of Knowledge Generating Resources, Routines, and Capabilities



This dissertation empirically focuses on knowledge generating resources and the firm's capabilities. Routines are theorized as a mechanism in which knowledge generating resources influence the firm's capabilities; however routines are not empirically tested. Further, firm performance is not tested in the hypothesized relationships, however I conduct additional analyses to validate that a firm's product development capabilities do influence the firm's performance.

Figure 1.1 builds on a recent model proposed by Eggers and Kaplan (2013) which proposes that experience is the sole driver of routines, which in turn influence firm capabilities. In my dissertation I build from their basic model and make new contributions with regards to how different sources of knowledge (i.e., experience and relational resources) influence firm capabilities. I contend that experience is only a single source of knowledge a firm can utilize, and that relational resources may be another important source of knowledge for the firm.

I propose three mechanisms that firms use to enhance their capabilities. First firms *assess* their capabilities and how well these capabilities can help the firm achieve its goals. Next, if the

firm determines that its current capabilities will be insufficient to achieve the firm's goals, then the firm *leverages* its knowledge generating resources in order to design new, or modify existing, routines. Finally the firm *implements* the routines it has designed or modified. These new or modified routines can enhance the capabilities of a firm, assuming these routines provide more value than prior routines.

1.2 Product Development Capabilities

In this dissertation, the particular firm capabilities I focus on are product development capabilities. Specifically, I focus on how firms can enhance the effectiveness, as well as efficiency, of their product development capabilities. The effectiveness of a firm's product development capabilities refers to a firm's capacity to develop highly desirable products, and the efficiency of a firm's product development capabilities refers to a firm's capacity to design and develop products quickly (Verona, 1999). Product development capabilities are important, and therefore deserve a serious examination, because they positively influence firm outcomes. Specifically, highly desirable products have been shown to increase a firm's profitability and decrease the variance in the firm's profitability (Kroll et al., 1999), allow the firm to extract a price premium (Buzzell & Gale, 1987; Kuzma & Shanklin, 1992), and increase both sales compared to competitors and customer satisfaction (Tatikonda & Montoya-Weiss, 2001). Additionally, winning a product quality award generates an abnormal positive stock market return (Hendricks & Singhal, 1996). Speed of product development allows a firm to be more nimble than its competitors, therefore giving it a superior position within an industry (Dacko et al., 2008). Fast product development speed may allow firms to gain a first mover advantage (Carpenter & Nakamoto, 1989; Lieberman & Montgomery, 1988; Kerin et al., 1992). Firms that get to market early in an industry have been shown to attain higher market share (Bowman & Gatignon, 1996; Robinson, 1988; Urban et al., 1986).

1.3 Knowledge Generating Resources as Antecedents to Product Development Capabilities

This dissertation explains how different types of knowledge generating resources, defined as resources that allow a firm to gain new levels of understanding of phenomena through their accumulation and utilization, influence a firm's product development capabilities. One important knowledge generating resource a firm can leverage to enhance its product development capabilities is experience (Eggers, 2012). While previous work suggests that experience influences a firm's routines, which in turn influence the capabilities of the firm (Eggers & Kaplan, 2013), this prior research does not test which types of experience are important to product development capabilities. Further, while experience is an internal knowledge generating resource a firm may utilize, firms in today's economy must look for external sources of knowledge to supplement their internal knowledge, particularly in the area of product development (Huston & Sakkab, 2006). This is because firms may not have all of the capabilities required for their product development goals, and important knowledge resources may lie outside the firm's boundaries (Dyer & Singh, 1998). Therefore it is important to examine the effects of external knowledge generating resources, particularly relational resources (Dyer & Singh, 1998; Lavie, 2006), in conjunction with a firm's internal resources on a firm's product development capabilities

1.3.1 Experience

Prior experience is a knowledge generating resource that provides a firm increased understanding of the casual effects of its actions and the outcomes from those actions. I consider four types of experience to be pertinent to the development of effective and efficient product development capabilities.

- Market Niche Experience – Defined as the amount of experience a firm has developing products for a specific customer segment (Eggers, 2012; Verona, 1999, Nerkar & Roberts, 2004).
- Component Technology Experience – Defined as the amount of experience a firm has with significant technologies within the firm's new products (Henderson & Clark, 1990).
- Platform Technology Experience – Technology platform architectures "lays out how all the components will work together" (Henderson & Clark, 1990, p. 2). Platform technology experience is defined as the amount of experience a firm has in developing complementary products for a specific technological platform.
- General Product Development Experience – This type of experience represents the depth of knowledge a firm has in product development and the establishment of product development routines (Lieberman, 1987; Nelson & Winter, 1982).

These four types of experience are important to study for several reasons. First, experience in specific market niches is important because prior studies have found conflicting results with regards to how market niche experience influences a firm's performance and had scant theory to explain those results (Nerkar & Roberts, 2004; Eggers, 2012). Separating experience with components from experience with platform technologies is important because I want to delineate between, and develop theory to describe the separate effects of, two important types of technical experience that previous research has not empirically examined (Henderson & Clark, 1990; Church & Gandal, 1992). Lastly, general product development experience has been shown to impact the *efficiency* of a firm's product development capabilities (Lieberman, 1987), but it is unclear if it is important in conjunction with the other types of experience.

I theorize that market niche experience, component technology experience, and platform technology experience will positively influence the *effectiveness* of a firm's product development capabilities. Market niche experience provides a firm with knowledge of their customers' desires (Powell, 1995; Dougherty, 1990; Cooper 1979). This knowledge can be leveraged by the firm, allowing it to alter its routines to better address its customers' needs. Component technology experience gives a firm knowledge that it can leverage to implement routines that allow the firm to utilize these components to their maximum potential, resulting in enhanced value for customers (Bhaskaran & Krishnan, 2009). Experience with platform technologies will provide the firm with knowledge of the platform's architecture, specifically how components within the platform work and how the firm's complementary products will work with the platform's architecture. This knowledge can be leveraged by the firm to increase the effectiveness of the firm's product development routines, which will enhance the firm's product development capabilities.

With regard to the *efficiency* of a firm's product development capabilities (i.e., speed of product development), I argue that experience with component technologies, platform technologies, and general product development experience will positively influence the efficiency of the firm's product development capabilities. Experience with component technologies will provide the firm superior understanding of how critical components operate (Henderson & Clark, 1990). This particular knowledge can be leveraged by the firm to design and implement routines that utilize those technologies in the firm's subsequent products more quickly. Experience developing complementary products for a platform will provide the firm with an understanding of how a platform operates. This knowledge allows the firm to modify its routines to more efficiently develop platform-compatible products. Finally, general product

development experience will allow the firm to be more efficient in its product development due to learning curve effects (Lieberman, 1987). This occurs because the firm's routines have been refined through multiple product development iterations, which increases the efficiency of new product development capabilities. However, some of the knowledge gained during development iterations will be redundant to gains from prior iterations. Therefore, I argue that the firm's prior experience in product development will generate diminishing returns in efficiency because the firm gains less new knowledge during each product development cycle.

1.3.2 Relational Resources

Relational resources are a knowledge generating resource that provides a firm access to knowledge it cannot create itself, or is too costly for the firm to create (Dyer & Singh, 1998; Lavie, 2006). I argue that two types of relational resources are pertinent to the development of effective and efficient product development capabilities (Verona, 1999).

- Platform Relational Resources –The relationship the firm has with the owner of the technology platform the firm is developing products for.
- Co-Developer Relational Resources –The relationship the firm has with other firms that are developing components or technology for the focal firm's product.

The *effectiveness* of a firm's product development capabilities will be improved by the relationships the firm has with co-developers because co-developers have specialized and unique knowledge the firm does not otherwise have access to. This knowledge can help the focal firm improve its routines and well as better utilize the components provided by co-developers. Co-developers are motivated to provide high quality products to earn prestige, recognition, or social capital within an industry (Nahapiet & Ghoshal, 1998), which may provide the co-developer with future work opportunities, as well as rents from knowledge sharing (Lavie, 2006).

When a firm develops complementary products for a platform technology, the *efficiency* of a firm's product development capabilities will be influenced by both the relationships the firm has with the platform's owner and the relationship the firm has with co-developers. A relationship with the platform owner may allow a firm to gain knowledge of the inner workings of the platform before competitors. Gaining this knowledge earlier allows a firm to gain a 'head-start' in complementary product development by being the first to modify its routines to take advantage of this new knowledge, therefore increasing the efficiency of the firm's product development capabilities. With regard to co-developer relational resources, a long history of working with a co-developer establishes routines of communication though human co-specialization (Williamson, 1985; Dyer & Singh, 1998). This continued communication over time creates a mutual understanding in terms of how the co-developers' components will be used in the firm's newest products. This mutual understanding and shared knowledge developed over time increases the efficiency of the routines firms use to communicate with co-developers, which leads to faster product development because the co-developer will go through fewer iterations of its component in order to meet the firm's expectations (Dyer & Singh, 1998).

1.3.3 Interactive Effects of Experience and Relational Resources on Firm Product Development Capabilities

Beyond the importance of understanding how different types of relational resources and experience affect a firm's product development capabilities independently, it is also important to understand the interplay of effects between relational resources and firm knowledge on a firm's product development capabilities. Different combinations of experience and relational resources may drive or hinder a firm's product development capabilities in ways that each knowledge generating resource may not do on their own.

First, I propose a *complementary* effect between the experience a firm has with a specific market niche and the relationship a firm has with co-developers on the *effectiveness* of the focal firm's product development capabilities. This will occur because as the firm has more knowledge of a market niche, and they will be able to leverage that knowledge to develop routines that will more accurately and clearly articulate their needs to their co-developers. This will allow the firm's co-developers to have higher quality information to more effectively develop their own components. In support of these arguments, sharing personal knowledge has been shown to improve the quality of projects (Haas & Hansen, 2007). In addition, the history of communication between the firm and its co-developers will make the transfer of information about the firm's needs more accurate (Williamson, 1985; Dyer & Singh, 1998). This in turn will provide the firm with higher quality components from their co-developers, enhancing the effectiveness of the firm's product development capabilities.

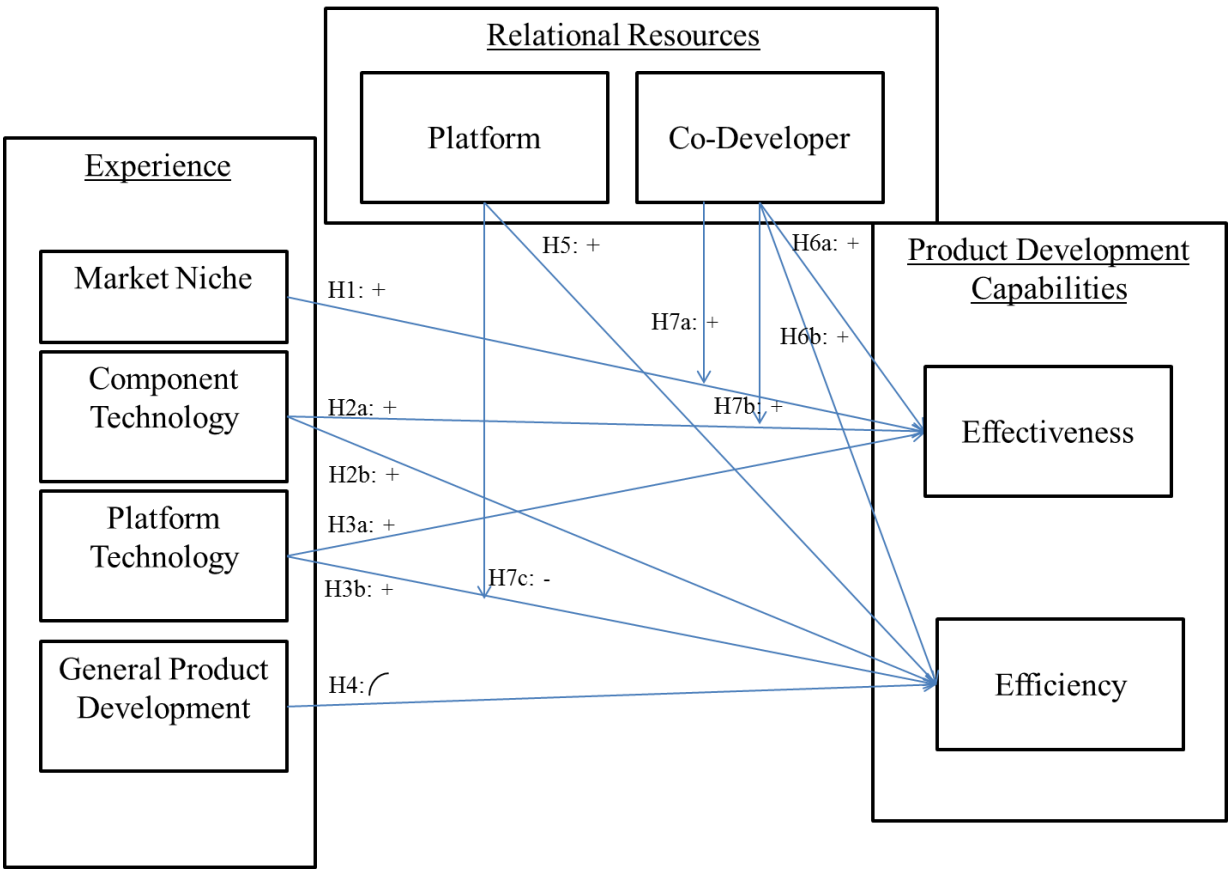
Second, I propose a *complementary* effect between the experience a firm has with critical component technologies and the relationship that firm has with its co-developers on the *effectiveness* of the firm's product development capabilities. The more experience the firm has with the critical technologies it is using within its products, the more knowledge the firm has of those technologies (Henderson & Clark, 1990). This knowledge is important for two reasons. First, the firm can leverage this knowledge to implement routines that communicate instructions to its co-developers more effectively on how to create the most compatible product components. Providing unclear instructions to suppliers has been shown to complicate product development (Gill & Wheelwright, 1997). Second, component knowledge allows the firm to understand how to optimize fit and function between co-developer components and their own technologies. Both

of these outcomes will reduce defects in the product and increase the effectiveness of the firm's product development capabilities.

Finally, I propose that there is an important interaction effect between the firm's experience and its relational resources on the *efficiency* of the firm's product development capabilities. Specifically, I propose a *substitution* effect between the firm's experience developing products for a platform and their relationship with a platform owner on the *efficiency* of their product development capabilities. If a firm has a relationship with a platform owner, the knowledge they gain from this relationship will increase the efficiency of the firm's product development capabilities (Dyer & Singh, 1998). However, the information gained from this relationship may be redundant if the firm already has product development experience with the platform technology. Redundant knowledge would not help the firm in developing or modifying its routines to enhance its product development capabilities (Hansen, 1999). Therefore, while a relationship with the platform owner may provide a firm with a short term efficiency benefit, experience developing products for platform can substitute for the knowledge a relationship provides.

Figure 1.2 below shows proposed relationships between the knowledge generating resources of experience and relationships on the effectiveness and efficiency of a firm's product development capabilities.

Figure 1.2: Conceptual Model of the Effect of Experience and Relational Resources on Firm Product Development Capabilities



1.4 Method

An ideal setting in which to explore these research questions would be an industry with (1) a large sample of products with data available on the quality of the products and the time it took to bring the products to market, (2) an industry that develops products for a technology platform, (3) a large sample of firms of varying sizes for which the experience of each firm in product development can be assessed, and (4) an industry in which a researcher can discern both the relationships a firm has with other firms that they are co-developing products with, as well as whether or not the focal firm has a relationship with the platform owner.

I use the setting of the video game industry as a context for this dissertation because the industry meets the criteria above. A recent study found that firms, as opposed to the individuals

in a firm, accounted for 21.3% of the variance in revenues for a video game (Mollick, 2012). This suggests that firm characteristics such as experience and relational resources may play an important role in determining firm performance in this industry. Additionally, there is a host of product level data and a large sample of small and large game studios/firms. Further, some game studios are affiliated with owners of game platforms (i.e. Microsoft with the Xbox platform and Sony with the PlayStation platform), which makes it possible to measure platform relational resources. In addition, many game studios co-develop products with other firms and utilize those firms to add technological components to their product. This data is noted in each of the game's credits. Finally, data is readily available regarding game studios' previous products, which allows me to track their experience developing products for different technology platforms, their history of use of technological components, their number of previous products, and their history of developing targets in different market segments.

Researchers often use subjective measures to describe a product's quality (Reeves & Bednar, 1994). The video game industry uses a MetaCritic score, which is a weighted average of multiple ratings of games, as a standardized indicator of game quality. This metric of product quality can serve as a signal of the *effectiveness* of the firm's product development capabilities. The speed of product development is another important product development capability (Lim et al., 2003; Ramaswami et al., 2009). When video games are released, the names of people who worked on the game are included in game credits and are accessible. The most important people in a game's development are the creative director and the game's producer. Using available information regarding these two key people, I am able to estimate the speed in which each game is developed by calculating the time between the top management team's last game release and the current release. This allows me to estimate the efficiency of the firm's product development

capabilities. Thus, given the availability of data about product quality, speed of development, relational resources and the firm's prior experience, the video game industry serves as an excellent context to test the effects of relational resources and the firm's prior experience on the firm's product development capabilities.

1.5 Contributions

This dissertation makes important contributions to various research areas: the product development and product development capabilities literature, the literature on how experience influences the development of capabilities, and the literature on how relational resources influence the development of capabilities. First, this dissertation explains how four types of experience influence a firm's product development capabilities. While prior studies have looked at the effect of some of these types of experience on product development capabilities (Eggers, 2012), no study has comprehensively studied all four of these types of experience in unison. Second, by examining how two types of relational resources, platform and co-developer, influence a firm's product development capabilities, I contribute to the literature on the effects of relational resources on product development capabilities. This contribution is important because the effects of relationships a firm has with platform owners and co-developers on the focal firm's product development capabilities and performance have not been studied from the point of view of firms that produce complementary products for platforms. Third, because I control for the human resources devoted to a product's development, I empirically contribute to the product development literature by providing evidence of whether or not relational resources and prior experience contribute to a product's development in an additive way with the human resources devoted to that product's development. This finding furthers our ability as product development scholars to disentangle the effects of knowledge provided by experience and relational resources

from the effects of other resources on a firm's product development capabilities. Fourth, and most theoretically important, I attempt to disentangle the 'black box' of interactive effects of prior experience and relational resources on a firm's product development capabilities. Lastly, I contribute to the resource based view's and evolutionary theory's ability to explain sources of competitive advantage. In all, this dissertation makes significant contributions to the product development literature by providing an in depth understanding of the effects of prior experience and relational resources on two important product development capabilities.

1.6 Boundary Conditions & Limitations

It is important to note boundary conditions to my theory. The theory and hypotheses of this dissertation are mainly concerned with sustaining technologies (Bower & Christensen, 1995). Radical innovations in a product segment may be very intense so that prior experience and relational resources may not impact a firm's product development capabilities as theorized in this dissertation. Additionally, the parts of this dissertation that relate to a firm's relationship with a technology platform's owner are only generalizable to the context of platform technologies.

An important limitation of this dissertation is that I do not empirically measure the knowledge of the firm or the routines of the firm. Instead, I follow common practice in the product development literature to examine outcomes (i.e., product quality and development efficiency) derived from knowledge (i.e., experience and relational resources) (Eggers, 2012; Nerkar & Robert, 2004). This is mainly due to the reluctance of firms to divulge their processes and practices due to fear of imitation.

1.7 Organization of Dissertation

The remainder of this dissertation will continue as follows. Chapter Two contains the literature review, which will examine previous research in product development capabilities, how resources and routines influences a firm's capabilities, and how experience and relational resources have been shown to influence a firm's routines and capabilities. Chapter Three develops my theory and hypotheses and provides the reasoning behind the hypotheses. Chapter Four discusses the methodology of my dissertation. The fifth chapter presents the results from the data analysis and tests the hypotheses developed in Chapter Three. Chapter Six concludes this dissertation by discussing the results of the dissertation, their implications and areas for future research.

2.0 LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature streams that are important for understanding a firm's product development capabilities starting with the broadest: literature that discusses firm capabilities. In section 2.2.2, literature that establishes that product development capabilities are important antecedents to firm performance is presented. The concept of antecedents to firm performance will be expanded by including literature on the resource based view and evolutionary theory, which suggest that resources and routines are performance antecedents. Recent theoretical developments suggest that prior experience and relational resources influence a firm's routines, so that literature will be discussed in section 2.3. In section 2.3.5, literature is reviewed to highlight the gaps in our understanding of how relational resources and firm experience influence product development capabilities. Finally, section 2.4 broadly reviews the literature regarding platform technologies, networks, and complementary products because there are theoretical gaps in those areas that this dissertation will investigate.

2.2 Capabilities

2.2.1 Definitions and Conceptualizations

Prior to discussing product development capabilities, the key construct in this dissertation, it is important to discuss capabilities and their origins more broadly. The concept of capabilities became popular with the introduction of the resource based view. Wernerfelt (1984) gave capabilities only a cursory mention, while Barney (1991) considered capabilities to be part of a firm's resources. In addition to capabilities, firm resources also included assets, processes, information, knowledge, and firm attributes that could "enable the firm to conceive of and

implement strategies that improve its *efficiency* and *effectiveness*" (Barney, 1991, p.101, emphasis added).

The ability to perform a task or activity has been regarded to be a capability (Helfat et al., 2007). One of the earliest definitions states that capabilities "refer to a firm's capacity to deploy resources, usually in combination, using organizational processes, to effect a desired end. They are information-based, tangible or intangible processes that are firm-specific and are developed over time through complex interactions among the firm's resources" (Amit & Schoemaker, 1993, p.35). Other scholars have defined organizational capabilities as "the ability of an organization to perform a coordinated set of tasks, utilizing organizational *resources*, for the purpose of achieving a particular end result" (Helfat & Peteraf, 2003, p.999, emphasis added). Capabilities have also been conceptualized as the "reliable capacity to bring about [some] thing as a result of intended action. Capabilities fill the gap between intention and outcome, and they fill it in such a way that the outcome bears a definite resemblance to what was intended" (Dosi, Nelson & Winter, 2000, p.2).

Recognizing that defining capabilities is difficult, recent work has proposed to "understand the statement that an organization has a specific 'capability' to imply that the organization (or its constituent parts) has the capacity to perform a particular activity in a reliable and at least minimally satisfactory manner" (Helfat and Winter, 2011, p. 1244). Helfat and Winter (2011) provide an important theoretical delineation between operational capabilities and dynamic capabilities. Operational capabilities are the capabilities "that enable a firm to make a living in the present" (Helfat & Winter, 2011, p. 1244). These capabilities allow a firm to reliably provide the same or similar goods and services to an established customer group. Dynamic capabilities, which were defined by Teece et al., (1997) "enable a firm to alter how it

currently makes its living" (Helfat & Winter, 2011, p. 1244). In contrast to operational capabilities, dynamic capabilities allow a firm to alter its operational capabilities, or its resources, to adapt to changes in the firm's external environment. This dissertation is primarily concerned with operational capabilities; specifically the ability of a firm to reliably develop highly desirable quality products quickly.

2.2.2 Product Development Capabilities and Firm Outcomes

Given this dissertation's focus on product development, it is important to ask: What are product development capabilities? While the phrase 'product development capability' has only become commonplace in the last fifteen years, research has examined the effects of product development capabilities since the 1970's. Product development capabilities refer to a host of desired product related tasks that a firm may be able to accomplish successfully and reliably. Marsh and Stock (2003) considered important parts of the product development process to include "concept development, product planning, product and process engineering, pilot production and ramp-up, and market introduction" (p. 138). Firms with superior product development capabilities may be able to do some, or all, of these processes either more effectively or efficiently than competing firms. With regards to producing products for international contexts, Subramanian and Venkatraman define transnational product development capabilities as "the ability to consistently and successfully introduce new products simultaneously in multiple country markets" (2001, p.361).

Two important product development capabilities have received considerable attention in the management literature: (1) the ability of a firm to design and create high *quality* products and (2) the ability of the firm to design and produce new products *quickly*. Verona described these two capabilities as product effectiveness and process efficiency (1999). product effectiveness

refers to how successful a newly developed product is in the marketplace. product effectiveness includes primarily the ability of a firm to create and deliver a highly desirable product of high quality to the market. Process efficiency refers to how proficiently a firm can design and develop new products. Process efficiency may be the speed in which a firm is able to develop new products, the number of new products a firm can have in development concurrently or the ability to keep development and unit costs low for a product. Verona (1999) contends that technological capabilities, such as R&D and manufacturing, influence a firm's process efficiency, whereas marketing capabilities influence a firm's product effectiveness. Verona's (1999) capabilities are similar Brown and Eisenhardt's (1995) two firm performance factors: product concept effectiveness and process performance. Product concept effectiveness describes how well a firm's products meet market needs given the firm's capabilities. Process performance reflects the "speed and productivity of development" (Brown & Eisenhardt, 1995, p. 366). In this dissertation I consider product effectiveness and process efficiency to reflect the effectiveness or efficiency of a firm's product development capabilities.

Of utmost importance to strategic management research is an understanding of if and how a resource or capability influences a firm's performance. The next sections examine the relationship between product development capabilities and firm outcomes. First, I review the effectiveness of product development capabilities; specifically conceptualizations of product quality and of the relationship between the ability to produce highly desirable products and firm outcomes. Next, I review the efficiency of product development capabilities; specifically the firm level outcomes that are derived from high speed product development.

2.2.2.1 Effectiveness of Product Development Capabilities

Product based outcomes have focused largely on how the *quality* of a firm's product is related to financial or market level firm outcomes. Therefore, it is important to review how quality, and more specifically product quality, has been conceptualized and studied in the past.

2.2.2.1.1 Definitions of Quality

Quality comes from the Latin root of *qualis*, meaning "how constituted" (Shewhart, 1931). A conception of quality as the 'goodness' of a product mostly likely goes back to the time of Aristotle (Shewhart, 1931). This 'transcendent' definition of quality attempts to suggest that superior quality is recognized when it is seen (Evans & Lindsay, 2002). However, Shewhart (1931) notes that this definition is too broad to be of any practical purpose.

One of the first researchers to examine product quality is Radford, who states "The term 'quality', as applied to the products turned out by industry, means the characteristic group or combination of characteristics which distinguishes one article from another, or the goods of one manufacturer from those of his competitors, or one grade of product from a certain factory from another grade turned out by the same factory" (1922, p.4). However, Shewhart (1931) notes that in this definition a product has "qualities and not a quality" (p.39). Shewhart (1931) argues that if a researcher can measure the quality of an object, it allows the researcher to do two things. First, the researcher can determine if the quality of a product differs between two time periods; and second the researcher can compare qualities of products from two or more time periods in the pursuit of determining whether or not differences in quality are due to chance or other reasons. Further, Shewhart contends that the quality of an object can either be defined objectively or subjectively. The subjective view of quality is closely linked to the ideas of value and utility, or the goodness of a thing. Shewhart (1931) claims that a subjective interpretation of quality is of

commercial interest to researchers because it informs us of whether or not our standards of living have changed. Therefore, there is a precedent to value *subjective* measures of quality from as early as Shewhart, who claims it was used as early as Aristotle.

Objective quality is included in Buzzel and Gale's (1987) two conceptualizations of quality: perceived quality and conformance quality. Perceived quality can be achieved by "developing a set of product specifications and service standards that more closely meet your customer's needs than your competitors" (p.104). This is a subjective view of quality. Conformance quality is "being more effective than your competitors to the appropriate product specifications and service standards" (p.104). Conformance quality is a more objective view of quality. These two definitions of product quality are not considered to be mutually exclusive.

Reeves and Bednar (1994) reviewed the quality literature and noticed four distinct viewpoints on quality. First, quality can be viewed in terms of a product achieving excellence. This viewpoint seeks to examine a singular characteristic of a product, such as the miles per gallon rating on a car, and compare that single attribute across all competing products. A second point of view on product quality is through a value-based lens, which factors both the value a consumer might derive from the attributes of a product and the price of the product as well. This is a utility based view of quality in which the consumer makes a cost and benefit calculation in his or her evaluation of that product. Reeves and Bednar's (1994) third proposed viewpoint of product quality is based on whether the product meets specifications and conformance requirements. This is similar to Buzzel and Gale's (1987) conformance quality. Finally, quality can be seen in a subjective light as the ability of a product to meet or exceed a consumer or user's expectations, similar to Buzzel and Gale's (1987) perceived quality. Despite the subjectiveness of this viewpoint, Reeves and Bednar (1994) note that subjective views of quality

are widely accepted by management scholars and are also the most common definition of quality in research, as seen in work by Clark and Fujimoto (1991) and Murray and Chao (2005).

2.2.2.1.2 Effectiveness of Product Development Capabilities and Firm Outcomes

If high quality products represent an outcome of effective product development capabilities, a major question remains to be answered: What benefits do firms derive from having high quality products? Recall Buzzell and Gale's (1987) two conceptions of quality from the previous section: perceived quality, which reflects a product's ability to meet a customer's needs, and conformance quality, which describes a product that meets specifications. The authors argue that perceived quality allows the firm to achieve a higher price premium. They found that firms whose product quality was in the top one-third of products commanded a 5-6% price premium over competing products in the lowest one-third. The authors argue that this price premium can either be (1) retained as profits, (2) reinvested into R&D to create more superior products, or (3) be abandoned, allowing the price premium to vanish and allow the product's price to be similar to competitors which will allow the firm to gain market share. Increased market share can lead to economies of scale in production, lowering per unit cost. Supporting this finding, the authors found that firms with the best quality tended to have costs similar to their competitors. Regarding conformance quality, the authors argue that when it is increased it will result in lower costs to the firm. Further, since customers desire reliable products, it may make a firm's product have a higher perceived quality, and therefore allow the firm to charge an even higher price premium.

Powell's (1995) study of firms that do and do not use total quality management (TQM) methods to improve product quality found that TQM programs can lead to economic value for a

firm, but some firms succeed without it. While TQM programs tend to seek strict conformance to specifications, which aligns with Reeves and Bednar's (1994) third viewpoint of quality, one executive interviewed in Powell's study stated that "If a company needs a fancy program to listen to their customers, then I think they'd better get one" (Powell, 1995, p.31). The quote highlights the importance of fulfilling a customer's desires, which mirrors Reeves and Bednar's (1994) fourth viewpoint of product quality as being subjective to each user or consumer.

Kuzma and Shanklin (1992) find product quality to be critical for medium market share businesses in gaining superior earnings and obtaining premium prices. In addition, stock markets also react favorably to higher product quality. Hendricks and Singhal's (1996) work demonstrated that firms are rewarded with above normal returns of between .59% and .67% of the stock price upon winning a product quality award. These findings are more indications of the importance of high quality products to a firm.

The previous studies in this section have focused on product-oriented firms. Interestingly, in a study on service oriented firms, Bharadwaji and Menon (1993) found that an increase in the quality of the service provided by a firm lowered the variance in a firm's returns, but increased quality did not increase the financial or market based performance of the firm.

Using a definition of product quality as "the characteristics of a product or service that can contribute to the fulfillment of stated or implied customer needs and wants" (Kroll et al., 1999, p.377), a definition similar to Reeve's and Bednar's (1994) subjective view of quality, Kroll et al., (1999) demonstrate, through a managerial survey of product quality, that higher quality products can create a competitive advantage for a firm. The authors find that products of higher quality not only increase the returns a firm receives, but also decrease the variance of those returns. Due to these findings, it seems that firms can potentially gain a competitive

advantage through the development of higher quality products (Kroll et al., 1999). Finally, increased product quality was also shown to increase the firm's sales relative to their competitors, as well as increase customer satisfaction (Tatikonda & Montoya-Weiss, 2001).

These findings suggest that the ability to design and produce high quality products can positively influence firm profitability (Kroll et al., 1999), provide firms a price premium (Buzzell & Gale, 1987; Kuzma & Shanklin, 1992), increase sales and customer satisfaction (Tatikonda & Montoya-Weiss, 2001) as well as generate an above-normal positive stock market return (Hendricks & Singhal, 1996). These positive firm outcomes suggest that firms should strive to create effective product development capabilities.

2.2.2.2 Efficiency of Product Development Capabilities

Equally important to the effectiveness of product development capabilities, as evidenced by product quality, is the relationship between the *efficiency* of a firm's product development capabilities and firm outcomes. The speed in which a firm can design, develop, and produce new products has been theorized to be an important capability for a firm (Tatikonda & Montoya-Weiss 2001; Murray & Chao 2005). The underlying intuition is that firms with fast development cycles are nimbler than their competitors and therefore are in a superior competitive position within the industry (Dacko et al., 2008). The superior competitive position may be due to the fact that firms that can develop new products faster may be able to gain first mover advantages (Carpenter & Nakamoto, 1989; Lieberman & Montgomery, 1988; Kerin et al., 1992).

First mover advantages may include locking customers into a technology choice that entails high switching costs if the customer desires to change technologies in the future (Carpenter & Nakamoto, 1989). Other first mover advantages include developing a new technological standard by having the first product in an industry or product category or being

able to secure scare assets (Lieberman & Montgomery, 1988). Technological advantages in a platform technology setting would include the ability to establish an 'installed base' of users before competitors are able to take action (Katz & Shapiro, 1985). Further, an installed base can hinder the development of competing technologies (Farrell & Saloner, 1986).

2.2.2.2.1 Efficiency of Product Development Capabilities and Firm Outcomes

Several studies guide our understanding of the effects of rapid product development capabilities on firm performance. The speed of new product development is typically measured as the time between the conceptualization of the product and the time the product is ready for the marketplace (Kessler & Chakrabarti 1996; Murray & Chao 2005). First, early studies found that firms that are the first to release their products gain more market share relative to their competitors (Bowman & Gatignon, 1996; Robinson, 1988; Urban et al., 1986). However, there is evidence that second movers can erase a first mover's market share advantage over time (Huff & Robinson, 1994). In addition, the shorter the time it takes for a firm to get new products to market, the more customers tend to be satisfied with those products (Tatikonda & Montoya-Weiss, 2001).

Rapid product development is an important capability for all firms, not only firms seeking first mover advantages. In a case study on Polaroid and their failed battle in the digital camera market, Tripsas and Gavetti (2000) claim that Polaroid was unable to develop fast product development capabilities which hurt their ability to compete with rival digital camera producers. The authors state that product innovations are released every few months in the electronics industry, a time frame Polaroid was not accustomed to in their historical market of

film based cameras. Therefore, fast product development was an important capability that Polaroid needed, but ultimately was unable to develop.

It should be noted that first movers often have disadvantages as well, such as the ability for follower firms to free-ride on the first mover's investments. Therefore, while rapid product development capabilities may lead to increased firm performance, researchers have noted that simply because a firm can create products quickly, it may not be best to release the products first due to free-rider effects as well as uncertainty in the market, technology and customer needs (Lieberman & Montgomery, 1988).

In sum, a firm's speed of product development may make a firm more nimble which may provide the firm with a superior position in the industry (Dacko et al., 2008), first mover advantages (Carpenter & Nakamoto, 1989; Lieberman & Montgomery, 1988; Kerin et al., 1992), as well as increased market share (Bowman & Gatignon, 1996; Robinson, 1988; Urban et al., 1986). Section 2.2.2.1.2 showed that the effectiveness of product development can lead to increases in firm performance (Kroll et al., 1999; Buzzell & Gale, 1987; Kuzma & Shanklin, 1992; Tatikonda & Montoya-Weiss, 2001). The results of effective and efficient product development capabilities on firm outcomes are summarized in Table 2.1 below.

Table 2.1: Literature on the role of Product Development Capabilities on Firm Performance

Author(s)	Product Development Capability	Measures	Firm Performance Outcomes
Bharadwaj & Menon, 1993	Effectiveness	IV = Service quality from PIMS; DV = ROI from PIMS	Service Quality decreased the variance in the firm's returns, but did not improve financial or market performance
Buzzel & Gale, 1987	Effectiveness	Use of PIMS database and variables	First, in the short run higher quality leads to an increased price premium. They found that firms whose product's quality was in the top one-third of products commanded a 5-6% price premium over the products in the lowest third. Second, in the long run higher quality products leads to higher volumes of products sold, which in turn can lead to economies of scale. They found that firms with the best quality tended to have costs similar to their competitors. Further, they contend that increased product quality leads to increased market-share.
Hendricks & Singhal, 1996	Effectiveness	Stock Price	Firms gained between .59 and .67 in abnormal stock price increase from the announcement of winning quality awards
Kroll et al., 1999	Effectiveness	IV= Manager survey of product quality DV = Average ratio of cashflow-to-total investment for the years of the study	Increased product quality leads to higher profitability and lower variance in profitability
Tatikonda & Montoya-Weiss 2001	Effectiveness & Efficiency	Survey to product managers	Product Quality, Unit Cost, and time to market lead to market outcomes. Quality and cycle time influence customer satisfaction positively (unit cost no effect). Quality and unit cost influence relative sales positively (time to market has no effect).
Bowman & Gatignon, 1996	Effectiveness & Efficiency	DV = Market Share, Product Quality = Consumer Reports	First entry gives more market share. Late movers can reduce price, improve quality, or promote more to compensate.
Lim et al., 2003	Efficiency	DV = Survey about firm's exporting activity; IV = use of computers to speed product development	Speed of new product development is a competitive advantage and is significantly related to the firm's level of export involvement.
Urban et al. 1986	Efficiency	ASSESSOR database examining entry of brands nationally. DV = Ratio of marketshare of each brand to the previous brand before it.	First movers gain more market share than late movers.

2.2.3 Origins of Capabilities

2.2.3.1 Resources

Scholars continue to debate the origins of firm level capabilities. The resource based view contends that a firm's resources are the ultimate source of what a firm is capable of (Wernerfelt, 1984; Barney, 1991). Resources are defined as "those (tangible and intangible) assets which are tied semipermanently to the firm" (Wernerfelt, 1984 p. 172). A main contention of the resource based view is that firms have heterogeneous resources which lead to differing levels of firm performance. Wernerfelt also suggests that firms want to control attractive resources either directly or indirectly in order to make it difficult for competitors to mimic the focal firm (1984). It is important to note that the relational view suggests that firms do not need to control resources, but benefits could be derived by accessing a partner's important resources (Dyer & Singh, 1998). Barney (1991) expands the resource based view by suggesting that for resources to provide a firm with a competitive advantage, they must be valuable, rare, inimitable, and non-substitutable.

One of the earliest arguments that resources specifically influence capabilities contends that capabilities "are information-based, tangible or intangible processes that are firm-specific and are developed over time through complex interactions among the firm's resources" (Amit & Schoemaker, 1993, p.35). The authors continue by stating that capabilities differ from resources because capabilities are rooted in carrying, exchanging and developing information through the firm's individual members; whereas resources are considered to be the stock of factors either controlled or owned by the firm and that these resources are eventually converted into a final product.

Recall Helfat and Peteraf's definition of capabilities as "the ability of an organization to perform a coordinated set of tasks, utilizing organizational *resources,* for the purpose of achieving a particular end result" (2003, p.999, emphasis added). This definition does not state that resources are the source of capabilities, but instead that resources are used to achieve a desired outcome. This is similar to the Amit and Schoemaker's (1993) definition referenced above.

Responding to criticisms of the resource based view that there is little theory explaining how firms transform resources to create value. Sirmon, Hitt and Ireland (2007) contend that firms create value through bundling resources to build capabilities. These capabilities are then leveraged to exploit opportunities in the market. The authors argue that firms are endowed with heterogeneous resources which are the firm's 'resource portfolio'. The resource portfolio contains tangible and intangible resources that can be purchased on the market, can be accumulated internally, and can be divested. These resources can then be bundled together to create or alter the firm's capabilities through three methods. First, resources can 'stabilize' capabilities by altering them incrementally. Second, resources can 'enrich' capabilities to enhance a capability beyond the level required to simply stay 'up to date.' The third method in which resources can be bundled to create capabilities is through 'pioneering' which is "the process of creating new capabilities with which to address the firm's competitive context" (p. 277). The authors continue by arguing that once a firm develops capabilities from resources, the firm is able to deploy those capabilities to create value for customers and wealth for owners. In a critical examination of Sirmon, Hitt and Ireland's (2007) theory, I argue that a firm would need capabilities to accomplish any of the three methods described above. Asking 'How would a firm achieve these initial capabilities?' results in a "chicken and egg" situation if capabilities are

assumed to be required to accomplish the processes Simon, Hitt and Ireland propose. Therefore, this dissertation attempts to make more nuanced arguments of how resources influence a firm's capabilities.

2.2.3.2 Routines

Although resources are more often cited as the source of firm capabilities, another stream of research proposes instead that capabilities arise from a firm's routines. Routines, as proposed by Nelson and Winter's evolutionary theory of the firm (1982), are "all regular and predictable behavioral patterns of firms" (p.14). A routine "may refer to a repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational individual performance" (Nelson & Winter, 1982, p.97). For a firm to do something productive, its members are required to have a repertoire or "a set of skills or routines that a particular member could perform in some appropriate environment" (Nelson & Winter, 1982, p.98). Members of a firm with the appropriate repertoire, when matched with specialized equipment that the members have the skills to use, can lead to firm capabilities (Nelson & Winter, 1982, p. 103). In this model, then, organizational capabilities are argued to come from routines. Other authors note that not all routines lead to capabilities. Routines may exist in a firm without a specific intended purpose, and may just be "the way things are done around here" (Helfat et al., 2007, p. 4).

If organizational capabilities come from routines, where do routines come from? Nelson and Winter contend that routines reside in the organization's memory, and organizations 'remember by doing' (1982, p.99). This suggests that a firm's *prior experience* may play a critical role in the development of routines, which can lead to organizational capabilities. Recall that even though Amit and Schoemaker contend that capabilities are developed through the

interactions of the firm's resources, the authors note that capabilities need time to develop (1993). This suggests that firm capabilities require experience and time to develop.

Recently, Eggers and Kaplan (2013) have argued that experience is the source of routines, and consider routines to the 'building blocks' of capabilities. Per their theory, routines are assembled and matched to the firm's external environment to enhance the firm's capabilities (detailed in section 2.3.1). However, I contend that while experience is an important resource which can be utilized to develop a firm's capabilities, experience alone is insufficient in industries that exhibit high paced product development, such as electronics and software development (Brown & Eisenhardt, 1995; Tripsas & Gavetti, 2000). Experience is only one resource a firm can utilize to develop routines that influence the firm's product development capabilities. In product development, the firm often times must look beyond its own borders to be innovative (Huston & Sakkab, 2006). Therefore, the firm should supplement internal resources, such as experience, with external resources to develop capabilities that allow the firm to remain competitive. Relational resources can provide new knowledge to a firm that it can leverage to develop or modify its routines. The implementation of these routines may create superior product development capabilities. Therefore, it is important to review the effects of both experience and relational resources on a firm's routines and capabilities.

It is important to note that there are other types of resources than firm experience and relational resources which may influence firm capabilities. Some of these resources include human capital (Schultz, 1961; Becker, 1963; Junkunc & Eckhardt, 2009) and R&D (Graves and Langowitz, 1993). While these are important areas of study, they are beyond the scope of this dissertation.

2.3 How Experience and Relational Resources Influence Routines and Product Development Capabilities

Resources and routines were established to be antecedents to capabilities in the previous section. This section examines the extant literature regarding how experience and relational resources, both of which are resources, influence firm level routines and product development capabilities. I conclude this section by highlighting important gaps in our understanding of how experience and relational resources ultimately influence a firm's product development capabilities.

2.3.1 Role of Accumulated Experience in Routine Development

Levitt and March (1988) propose that "The *experiential* lessons of history are captured by *routines* in a way that makes the lessons, but not the history, accessible to organizations and organizational members who have not themselves experienced the history" (p.320, emphasis added), and therefore contend that experiential learning culminates in routines (Nelson & Winter, 1982). Strategic management literature suggests that experience influences organizational capabilities (Helfat & Lieberman, 2002). Organizational learning scholars also contend that capabilities are influenced by experience (Argote, Beckman, & Epple, 1990).

But an important question remains, specifically what are the mechanisms by which experience leads to organizational capabilities? Recent theoretical work suggests that the firm's prior experience, in conjunction with the cognition of the firm's managers, leads to the 'construction' of routines within the firm (Eggers & Kaplan, 2013). Next, managers 'assemble' the routines in a way to maximize the value of the capabilities that result from the routines.

Finally, managers attempt to 'match' the capabilities of the firm to the environment in which the firm exists (Eggers & Kaplan, 2013).

It is important to be more specific about the first mechanism that Eggers and Kaplan (2013) describe: The construction of routines based on prior experience. The authors highlight three behavioral mechanisms that influence how experiences are encoded into routines. The first mechanism is that managers select routines that they believe have led to successful outcomes in the past. It is argued that experiences associated with successful outcomes have a higher likelihood of being encoded into routines than experiences which were less successful (Levinthal & March, 1993). Second, Eggers and Kaplan argue that experiences that are associated with the firm's current routines and knowledge are easier to encode and store. This concept is related to core ideas in the absorptive capacity literature which suggests that firms are able to identify new knowledge as valuable and utilize that knowledge when the new knowledge is similar to the firm's current knowledge (Cohen & Levinthal, 1990). Finally, experiences with a higher frequency are easier to encode and recall in the future than rarer events. This assertion has its theoretical basis in the learning curve literature which suggests that high frequency events may improve a firm's performance during those events (Argote, 1999; Argote & Epple, 1990). Eggers and Kaplan argue that these three behavioral mechanisms will influence how managers recall and interpret prior experience, which will influence how managers develop routines to achieve a desired outcome (2013).

2.3.2 Role of Accumulated Experience in Product Development

A firm's previous experience in developing new products has been shown to influence the firm's product development capabilities. Examining contract research organizations (CROs)

utilized by pharmaceutical firms, it has been found that "CROs with more experience in a particular therapeutic area appear to develop both specialized technological knowledge and general common knowledge, such as problem solving and decision-making approaches, that can be drawn on in subsequent and similar development efforts" which suggests that experience enhances the firm's product development capabilities (Macher & Boerner, 2006, p. 861). Another study by the same authors found that more experienced firms have more effective 'learning by doing' approaches and better absorb important knowledge to solve problems the firm faces (Macher & Boerner, 2012). These examples highlight that previous experience allows firms to develop routines that can be useful in the future.

With regard to the effectiveness of a firm's product development capabilities, an important marketing study found that the more a focal product was similar to previous products the firm has experience in developing, the higher the initial financial success of the product will be (Moorman & Miner, 1997). MacCormack, Verganti, and Iansiti studied the effects of experience in the software development industry, using a sample of 29 Internet projects, and found that the generational experience of the development team, where generational experience is indicated by how many generations of a product's architecture an engineer had worked on previously, was associated with higher levels of product quality as measured a panel of experts (2001). An additional study found that only certain types of market experience aided the product's financial performance when the firm, but experience with technologies closely related to the current product did improve the product's financial performance (Nerkar & Roberts, 2004).

Relating prior experience to the efficiency of product development capabilities, one recent study found that previous technological experience has shown to reduce the time in which

it takes a firm to develop a product (Macher & Boerner, 2012). In addition, scholars have argued that a firm's ability to successfully release new products is due to the firm's experience in the technology behind the product as well as their experience in a certain product market (Nerkar & Roberts, 2004). There is also evidence to suggest that when firms gain experience adapting products to new market niches, the firm's ability to adapt its products to subsequent market niches in the future is enhanced (Eggers, 2012). Finally, if firms attempt to develop products for a broad scope of areas, but have relatively little accumulated experience in any area, they tend to face performance penalties in the form of slower product development (Macher & Boerner, 2006).

All of these studies suggest that firms with increased experience in an area of product development may perform better in that area in the future, but it depends on the type of experience the firm has. Therefore, there is research to support a model in which different types of experience can influence different types of firm product development capabilities, a key contention of this dissertation.

2.3.3 Role of Relational Resources in Routine Development

The main proposition of this dissertation is that internal and external resources can influence the routines of a firm, and those routines influence the product development capabilities of the firm. Experience is an internal resource that a firm may leverage to enhance its routines and capabilities. This dissertation highlights relational resources as an external resource that firms can utilize to improve their routines, and therefore their product development capabilities.

The relational view proposes that critical resources that influence a firm's performance may reside outside of the firm's boundaries (Dyer & Singh, 1998). The central thesis of the relational view is that independent firms can work together to generate relational rents. Relational rents are in actuality quasi-rents in which they provide short term profits above opportunity cost and next best use. Hence, relational rents are not permanent in nature. However, the relational view argues that relational rents can be semi-permanent since the sources of the rents are idiosyncratic and difficult for competing firms to achieve on their own or imitate. The achievement of relational rents can come from four sources: relation-specific assets, knowledge-sharing routines, complementary resources or capabilities, and effective governance (Dyer & Singh, 1998). The relational view is not solely focused on dyadic relationships, but also on the network of relationships a firm has with other firms. It is important to note that because the relational view emphasizes the importance of having *access* to resources outside of the firm's boundaries, it has caused some scholars to consider the relational view an extension of the resource based view. However, some scholars suggest that the relational view may be a theory in of itself (Mesquita, Anand & Brush, 2008).

The first source of relational rents, relation-specific assets, draws heavily from the work of Williamson (1985). Williamson argues that three characteristics of assets influence the optimal governance structure of a transaction: site specificity, physical asset specificity, and human asset specificity. The relational view (Dyer & Singh, 1998) proposes that firms that invest in each type of asset specificity can reap inter-firm relational rents. According to this view, site specificity can lower coordination costs through lower inventory and transportation costs. Further, investments in physical asset specificity (i.e., investments in assets specific to a single firm in their network), can lead to improved *product quality* from increased "product integrity or

fit" (Dyer & Singh, 1998 p.662 emphasis added). Finally, investments in human asset specificity allows for more efficient communication between individuals and therefore can lead to relational rents through the reduction in communication errors which may increase *quality* and *speed* to market (Dyer & Singh, 1998; Ananuma, 1989; Dyer, 1996).

The relational view suggests that inter-firm knowledge sharing routines may influence the routines of a firm. Inter-firm knowledge sharing routines are defined as "a regular pattern of inter-firm interactions that permit the transfer, recombination, or creation of specialized knowledge (Grant, 1996)" (Dyer & Singh, 1998, p. 665). However, it is important to understand the mechanisms in which relational resources can influence a firm's routines. More recent work combining the relational view with the resource based view has advanced theory as to how firms can gain competitive advantages through alliances. Lavie (2006) outlines four sources of rent for firms in alliances: (1) internal rents, (2) appropriated relational rents, (3) outbound spillover rents, and (4) inbound spillover rents. Internal rent refers to the rents a firm can create on its own without an alliance partner. These are typically Ricardian and quasi-Ricardian rents. Appropriated relational rent is the rent generated by two firms working together which neither firm could produce on its own. Outbound spillover rents are similar to inbound rents, but the alliance partner gains from unintended transfer of resources from the focal firm. Inbound spillover rents refer to rents that are gained by the focal firm from shared and non-shared resources, potentially knowledge, that unintentionally transfer (or 'spill over') from an alliance partner to the focal firm, allowing the focal firm to improve its resources or capabilities and generate value from them. Gains from spillover rents are argued to be controlled by opportunistic behavior by the firms as well as isolating mechanisms (Lavie, 2006). Therefore, the mechanisms in which a firm can gain knowledge from its alliance partners are through knowledge sharing

routines, which provide knowledge to the focal firm through both 'appropriate relational rent' and 'inbound spillover rent'.

When a firm allies itself and forms relationships with other firms, the focal firm can gain know-how from its partners (Kale, Singh & Perlmutter, 2000). Firms can utilize this knowledge to improve their own routines. In an example of how relational resources can influence the routines of a partner firm, Mesquita, Anand and Brush (2008) found that in buyer-supplier relationships, when a buyer trains their supplier in production techniques (a modification of the supplier's routines), trained suppliers outperform untrained suppliers. However, what is interesting is that this training did not 'spillover' to increase the supplier's ability to service other buyers. There were gains in performance that were exclusive to the buyer that trained the supplier (Mesquita, Anand & Brush, 2008).

Other capabilities that can result from relational resources, due to routine modification, include reduced transaction costs (Hennart, 1988), as well as an increased ability to adapt to a changing environment (Uzzi, 1997). It has also been suggested that relationships can be sources of competitive advantage because they can provide information, ideas, and opportunities (McEvily & Zaheer, 1999). Interestingly, firms with highly developed internal capabilities gain more benefits from external resources than firms with weak internal capabilities (Cohen & Levinthal, 1990).

2.3.4 Role of Relational Resources in Product Development

The relational view notes that a firm's alliance partners can be "the most important source of new ideas and information that result in performance-enhancing technologies and innovations" (Dyer & Singh, 1998 p. 665). Previous studies have found that knowledge sharing

routines can help a firm in product innovation. For instance, Powell (1996) found that innovation occurred more broadly at the network level than at an individual firm level in the biotechnology industry. In addition, von Hippel (1988) found that the majority of innovations in the wire termination equipment industry could be traced to suppliers.

One area in which the relational view consistently aids scholars is in examining the gains from relationships between suppliers and manufactures. Dyer and Nobeoka (2000) examined the sharing of knowledge within Toyota's supplier network, and found that it limits free riding and efficiently improves the transfer of both explicit and implicit knowledge. Gulati and Sytch (2007) examined the dependence of manufacturers on their suppliers and of suppliers on their customers. They found that when both parties are jointly dependent on one another, the procurement relationship provides additional benefits to the manufacturer. When the manufacturer has a dependency advantage in the relationship, procurement performance diminishes. However, when the supplier has a dependency advantage in the relationship, there is no effect on procurement performance.

With regards to developing new products, when firms are either technologically weak or do not have diverse technological knowledge, having relationships with knowledge-rich firms increases their ability to generate breakthrough innovations (Srivastava & Gnyawali, 2011). Ahuja (2000) found that inter-firm alliances provide resource sharing, which allows firms to share knowledge and skills. Further, Ahuja (2000) found that the links between alliance partners provided avenues of knowledge spillovers; alliance partners gained from innovation breakthroughs, as well as gaining knowledge to solve problems and learning about failed approaches to problems.

The relational view is applicable to many contexts. Firms in emerging industries often leverage relationships with other firms in order to gain a competitive advantage. For example, social networking service firms that engage more third parties in developing complementary products for their platform tend to have higher performance (Gnyawali, Fan & Penner, 2010). It is argued that this high level of firm performance occurs due to the collaborative knowledge sharing relationships the social networking service has with third party developers. These third party developers create additional content and applications for the social network's platform, which will attract new users, retain existing ones, expand the network base, and satisfy clients (Gnyawali, Fan & Penner, 2010).

Table 2.2 below summarizes how relational resources, as well as prior experience, influence the product development capabilities of a firm.

2.3.5 Gaps in How Experience and Relational Resources Influence Product Development **Capabilities**

From a theoretical perspective, further examination of the role of the firm's accumulated experience in product development is important because although the field has a long history, significant strides have been made in recent research (Eggers, 2012; Eggers & Kaplan, 2013). These new insights regarding how experience influences a firm's capabilities provide new opportunities to explain how different types of experience influence a firm's product development capabilities. In addition, the relational view is a relatively new theoretical viewpoint compared to the other resources that may influence a firm's routines, such as human capital (Schultz, 1961; Becker, 1963) and experience (Eggers & Kaplan, 2013). Therefore, there

Table 2.2: Literature on the Role of Experience and Relational Resources on Product Development Capabilities

Author(s)	Type of Resource	Measures	Key Findings
Nerkar & Roberts 2004	Accumulated Experience	Market Experience = Years of Experience in last 10 yrs. Technological Experience = # of patents in last 10 years. DV = Initial Sales	Technological knowledge is sufficient for a given product area, but when the firm wants to combine knowledge from different areas for a new product, they require market knowledge as well. Proximal and distal market niche experience aids performance of generic products. Only distal maket niche experience aids performance of novel products.
Macher and Boerner 2006	Accumulated Experience	DV = time to completion; Experience is in a therapeutic area	Firms with experience in an area gain specialized technical knowledge as well as general knowledge (such as problem solving) which reduces the speed of development.
Eggers 2012	Accumulated Experience	New product quality is return on a fund.	The more experience adapting to new markets, the easier is for the firm to do so in the future.
Macher & Boerner, 2012	Accumulated Experience	DV = completion time. Experience = in a therapeutic area.	Firms can outsource well developed problems, but should work in-house on ill-structured problems. Previous experience reduces time to develop a product.
Kale and Singh and Perlmutter, 2000	Relational Capital	Multi Item scales for RC in appendix	Relational capital leads to increased learning and protection of proprietary information
Srivastava & Gnyawali, 2011	Relational Capital	NBER patent data. Rate of breakthrough innovations.	The diversity and quality of technology resources in a firm's alliance portfolio aids the development of breakthrough innovation. Maximum benefits for firms with low strength and diversity.
Gnyawali, Fan, Penner, 2010	Relational Capital	Performance = Website views	Platform co-development (engaging third parties via knowledge sharing to develop for the platform) increases firm performance.
Dyer & Nobeoka, 2000	Relational Capital	Case study approach w/ Toyota	The establishment of strong ties among a supplier network motivates the network participants to share knowledge, limits free riding, and makes the transfer of implicit and explicit knowledge easier
Gulati & Sytch, 2007	Relational Capital	Interviews and Survey	When the two parties are jointly dependent, there are performance benefits in procurement. When the manufacturer has an advantage, there are diminished returns. When the supplier has an advantage, there is a null effect.
Mesquita et al., 2008	Relational Capital	Surveys to measure how and if cost savings due to sharing of knowledge are distributed evenly	Trained suppliers outperform untrained ones. Not all knowledge transfers to suppliers permeates to all buyers.

remains a great deal that is unknown regarding the effects that different types of relational resources can have on a firm's product development capabilities. Lastly, focusing on prior experience and relational resources allows me to contrast the effects of internal and external resources on a firm's product development capabilities. This contrast of internal and external resources is important because it may further our understanding of the importance of external resources as compared to internal resources, and vice versa.

There are many *types* of prior experience that may influence a firm's product development capabilities. Some of these experiences include a firm's prior experience in product development (Moorman & Miner, 1997; MacCormack, Verganti, & Iansiti, 2001), a firm's prior experience developing products for a technological platform (Church & Gandal, 1992), a firm's prior experience with a critical technology they will use in a product (Henderson & Clark, 1990), and a firm's expertise with a specific market segment which may provide the firm with unique knowledge of what that customer segment desires (Eggers, 2012; Nerkar & Roberts, 2004). While each of these has been examined in a single study, there is no study that examines any of these effects in combination. Without examining multiple types of experience we do not have a thorough understanding of the incremental effects of each type of experience in combination with other types of experience.

Examining the effects of different *types* of relational resources, specifically the effects of relationships with outside component developers as well as platform owners, on a firm's product development capabilities remains an area in which the field does not have a great deal of knowledge. For example, are relational resources that provide knowledge of a platform the focal firm is developing products for more important to a firm's product development capabilities than relationships the focal firm has with firms that are co-developing components and technologies?

Therefore, understanding if and how different types of relational resources enhance a firm's product development capabilities is of importance to the product development literature.

Further, it is unclear how different types of accumulated experience and relational resources interact or jointly influence a firm's product development capabilities. For example, do technological relational resources (platform and component) aid younger firms by providing knowledge of a technology quickly, or does experience supersede the effects of technological relational resources as the firm continually uses that technology to develop new products (a substitution effect)? Or do relational resources help a firm throughout its product development in addition to the experience effects the firm receives (creating a complementary effect)? In addition, understanding how a firm's experience with their co-developers influences a firm's product development capabilities would be an important insight because it combines the effects of both experience resources and relational resources. Relatedly, several recent studies highlight the importance that prior experience has on a firm's capability to perform activities with regards to product development in the areas of alliances (Hoang & Rothaermel, 2010) and acquisitions (Zollo & Reuer, 2010). These recent findings suggest that a firm's routines, and therefore capabilities, may be derived from a firm's prior experience with alliance partners. Therefore, there are several gaps in our understanding of how different types of experience and relational resources independently and interactively influence a firm's product development capabilities. Answering the questions above would further the product development literature as well as contribute to our knowledge on the dynamics of developing products for platform technologies.

2.4 Review of Literature on Platforms, Installed Bases, Networks and Complementary Products

The hypotheses of this dissertation will be tested in the context of firms that develop complementary products for specific technological platforms. To understand the nuances of

complementary products, platform technologies, and networks, the following sections define and briefly overview major concepts related to each. At the end of this section, I highlight important theoretical gaps specific to platform technologies that this dissertation will be useful in addressing.

2.4.1 Platforms, Installed Bases, and Network Effects

A platform technology provides an architecture (i.e., rules and syntaxes) that allows firms or users to develop products and services that can be utilized on the platform. For example, the Windows operating system, a platform, allows Microsoft and other software developers to create applications that run on Windows. Firms that make platforms tend to compete in multi-sided markets in which they compete for users to purchase and use the platforms, but also need to attract firms to develop products for their platforms (Evans, 2003; Zhu & Iansiti, 2012; Rochet & Tirole, 2003 & 2006). A network of users develops when a technology allows users to connect to one another, such as through the internet with Windows, or via telephones over a telephone company's technological platform. The size of this network of users is commonly referred to as the 'installed base' (Schilling, 2010). The size of the installed base can lead to positive and negative network externalities that influence the users of a platform, technological platform owners, and firms that create complementary products and services for a platform (Schilling, 2010).

Katz and Shapiro (1985) argue that users of platform technologies should be concerned with the installed base of the platform and complementariness of products for three reasons. First are direct consumption externalities, which is the utility a user derives from a platform is directly dependent on how many others are on the same technology network. This may be best illustrated in the size of the installed base using a telephone. Telephone owners would desire a bigger

network so they can call more people. Second, there are also indirect network externality effects that influence a platform. If an installed base for a platform is low, a user may have concerns that complementary products for the platform may not be developed by other firms. This can occur in industries such as videogames in which game developers have little economic incentive to develop products for video game platforms with low installed bases. Finally, Katz and Shapiro (1985) argue that the installed base of a product may influence how easy it is to get the product serviced. The authors highlight automobiles as an example. The more of a make and model of an automobile sold, the more likely there will be replacement parts for the vehicle, and the likelihood of the automobile company surviving to continue to provide service increases. It has been found that if consumers believe one technology platform to be dominant or have a larger installed base, they are willing to pay a premium for that platform (Katz and Shapiro, 1985). This in turn helps the platform technology to become even more dominant as more consumers purchase it and further increase the installed base.

Katz and Shapiro note that there are private and social benefits to joining a network (1994). The private benefits accrue to the user joining the network, and they will only join if the benefits outweigh the cost of joining. However, there are social benefits to all users of the network by having another compatible user in the network which existing users might be able to interact with. Using an economic model, Chou and Shy (1990) argue that consumers benefit from larger networks not because users are all using the same brand/technology, but because there are more complementary services and products developed for that brand/technology.

One of the first academic works on network effects was Rohlfs' (1974) research on telephone networks. Rohlfs noted that users of the telephone gained 'external economies of consumption' as more people owned telephones. More recently researchers refer to this

phenomenon as network externalities (Schilling, 2010). Liebowitz and Margolis (1994) make several important insights regarding potential downsides to an increased installed base. These downsides are known as negative externalities. For example, when too many people (the installed base) attempt to use a road (a platform) at once, it results in traffic. The platform cannot handle that many users at one time. Negative externalities can occur with the telephone network when a lot of people use it at once; the telephone network can be flooded and a user would not be able to place a call. Due to these negative externalities, Liebowitz and Margolis (1994) argue that all network externalities cannot be treated equally and there needs to be refinement of terms so that researchers can better understand what influences the value of a network.

2.4.2 Complementary Product Development

With regard to firms that develop products for a platform, Church and Gandal (1992) examine the factors that influence a firm, such as a software developer, to produce complementary products for one technology platform instead of another. Church and Gandal (1992) contend there are two effects influencing this decision. The first is the network effect, in which the firm will want to create products for the technology with the larger installed base because they want a large consumer base. The authors contend that this will result in a single dominant technology. However, the authors argue that there is a competitive effect. If more firms release products for a single platform, the market for complementary products will become more competitive. This in turn lowers the sales and profits of a firm, which would cause the firm to consider developing complementary products for another technology that is less competitive (Church & Gandal, 1992).

In a subsequent study, Church and Gandal (1993) find that the cost of developing complementary products influences the platform that will become dominant. They contend that if

a particular platform has high development costs for complementary products, those costs limit the number of firms that can create complementary products. Since this will result in a low number of complementary products for the platform, the consumer adoption of the platform will be low. Church and Gandal's (1993) model uses software providers as a context and assumes that software firms are Bertrand competitors in which software firms set prices and consumers choose the quantities in which to buy products at those prices. In contrast, Katz and Shapiro (1994) highlight that if complementary products are subject to declining marginal costs, either by economies of scale or learning effects, a larger installed base will lead to greater complementary product sales and a lower cost of complementary products, as well as lower prices. Further, they contend that a larger installed base may lead to a greater variety of complementary products, or higher quality complementary products due to competition.

When firms that seek to create products or services for a technology platform, such as a software developer deciding whether or not to develop software for the PC or Macintosh, there are several factors to consider other than installed base. Katz and Shapiro (1986) introduced the concept of a platform or technology sponsor, which is the firm, or entity, which has the rights to the platform technology and therefore may be willing to make investments in the technology. The authors make some interesting findings regarding sponsors. First, when competing technologies have no sponsors, the dominant technology of today will remain dominant. Second, when one of two technologies is sponsored, that technology has a strategic advantage and other firms may adopt it even if it is inferior in a technological sense. Third, when two technologies are sponsored, the technology that will be superior in the long run will have the strategic advantage (Katz & Shapiro, 1986).

The quality of a technological platform is also an important factor to consider when choosing a platform to develop products for. Economides (1996) finds that the quality of different technologies in a network affects the quality of the entire network. For example, the clarity of long distance calls depends on the quality level of the minimum technology supporting the call.

2.4.3 Gaps in the Platform, Installed Base, Network and Complementary Products Literature

Gnyawali et al.,(2010) found that social network platforms that engage with third party developers attain higher levels of firm performance. It is claimed that firm performance will increase because "the improvement of service quality and increased service offerings through new applications will have a paramount impact on user adoption and user retention" (p. 599) as well increase the network's size and better address their client's needs. The authors note that "prior research (Fornell et al., 1996; Anderson et al., 2004; Cronin et al., 2000) suggests that an increase of service quality will improve the perceived usefulness of the service or perceived value by potential users, which, in turn, will increase the chances of adoption by new users (Bhattacherjee, 2001; Davis, 1989; Venkatesh et al., 2003; Wixom & Todd, 2005)." The authors imply that co-development increases the platform's quality but do not examine a measure of quality. The quality of the products that co-developers create may be important to a platform, but the study assumes that the quality of the relationship between the platform developer and third party developers is the same for all developers. This may not be accurate and therefore this dissertation advances our understanding of how different relationships between platform owners and co-developers influence the quality of products produced for the platform

These gaps provide three ways for this dissertation to make important contributions to the platform literature. First, I examine the quality of the relationship between a platform owner and a third party developer, which may produce important insights regarding how those relationships may impact a firm's product development capabilities. For example, there are many factors influencing the decision of which platform a firm should develop products for. Platform owners need third party firms to develop content for their platform, in order to attract and retain users (Gnyawali et al., 2010). However, what is less clear is whether or not a third party should choose to develop for one platform, or for multiple platforms. If a firm decides to develop a product for only one technological platform, they forego potential revenue from placing their product on multiple platforms. However, it may be possible that a third party firm could adopt a strategy to develop for one platform, cognizant that doing so will decrease their potential customer base, but hope to gain from relational-asset specific rents, and potentially acquire and utilize knowledge regarding that single platform at a faster rate, which may make their R&D processes more efficient. In addition, drawing the literature from accumulated experience and product development, these 'specialized' firms may produce higher quality products more quickly than competing firms due to their specialized accumulated experience, which may reduce their costs and enhance their revenues on their specialized platform. Second, Gnyawali, Fan & Penner (2010) used the platform owner as the focal firm. This dissertation focuses on the third party firms that develop complementary products for the platform, which provides a new perspective to the literature. Finally, this dissertation examines how prior experiences with outside firms influence the third party firm's product development capabilities in a platform context. This merges the extant literature on experience and relational resources.

2.5 Conclusion

This chapter has reviewed literature on the constructs and concepts pertinent to this dissertation. First, I reviewed the concept of capabilities, specifically product development capabilities and their influence on firm outcomes. I then highlighted the resource based view and evolutionary theory as theoretical lenses in which to study how resources and routines may influence a firm's capabilities. Next, I reviewed the extant literature on two important resources, accumulated experience and the firm's relational resources, with regard to how they influence a firm's routines and capabilities. Finally, I highlighted important concepts in the platform and technology network literatures that are relevant to the types of relational resources examined this dissertation.

This review clearly shows various gaps in the platform technology literature. Specifically, limited literature examines the interactive effects of relational resources and accumulated experience on a firm's product development capabilities. In addition, there are interesting theoretical questions in the context of platform technologies, specifically the process, and consequences, of a third party developer's decision to ally with a platform owner and develop complementary products exclusively for a single platform. These decisions can have important implications for the capabilities of third party developers as well as for the ability of platform owners to attract third party developers. In the following chapter I draw on the literatures reviewed in this chapter and develop theory to address these questions.

3.0 THEORY DEVELOPMENT

3.1 Introduction

Understanding the sources of competitive advantage is one of the key areas of strategic management research (Penrose, 1959; Wernerfelt, 1984; Barney, 1991). This dissertation focuses on product development capabilities as a source of competitive advantage because product development capabilities are important antecedents to various firm performance outcomes such as increased firm profitability (Kroll et al., 1999), increased sales and customer satisfaction (Tatikonda & Montoya-Weiss, 2001), first mover advantages (Carpenter & Nakamoto, 1989; Lieberman & Montgomery, 1988; Kerin et al., 1992) and increased market share (Bowman & Gatignon, 1996; Robinson, 1988; Urban et al., 1986). Building upon the literature review discussion that product development capabilities are created and enhanced by resources, this chapter further develops the concept of product development capabilities and proposes a theoretical model of how firms leverage knowledge generating resources such as experience and relational resources to enhance their routines which improve their product development capabilities. The specific research questions this dissertation examines are the following:

4. How do different types of product development experience influence a firm's product development capabilities?
5. How do relational resources pertinent to product development influence a firm's product development capabilities?
6. How do experience and relational resources jointly interact to influence a firm's product development capabilities?

As detailed in Chapter Two, current research suggests that experience and relational resources have direct effects on a firm's product development capabilities. This dissertation advances the field's current understanding in two important ways. First, I examine the individual and combination effects of different types of experience and relational resources on different types of product development capabilities, which other studies do not. Second, with a focus on the context of firms developing complementary products for a platform, this dissertation attempts to explain more fully than past studies how and why experience and relational resources influence a firm's product development capabilities.

3.1.1 Boundary Conditions

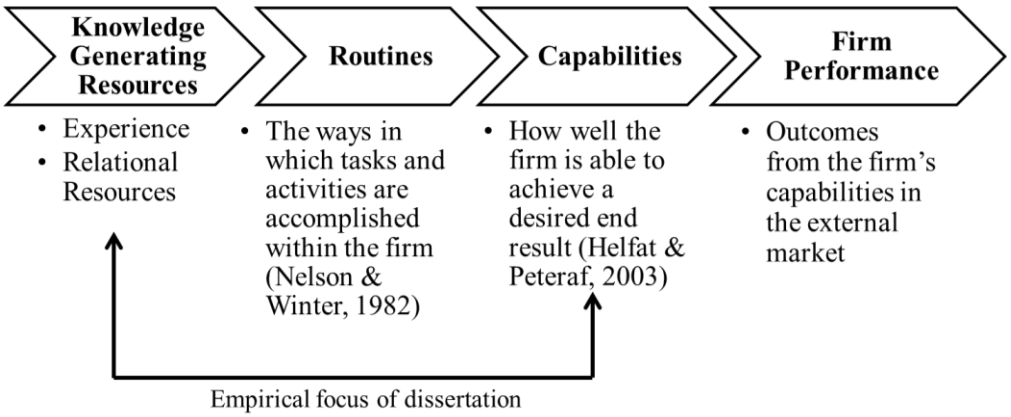
It is important to establish the boundary conditions for this theory. Specifically, this theory applies primarily to sustaining technologies. Sustaining technologies are well established, have a known customer segment, and their trajectory of performance can be estimated reasonably well (Bower & Christensen, 1995). This study's hypotheses do not apply to product markets that have recently experienced breakthrough or disruptive innovations. In such markets, effects from breakthroughs and disruptive innovations may radically influence the effectiveness and efficiency of a firm's product development capabilities. In addition, aspects of the theory, such as the role of platform experience and relations with platform owners, will only apply in the context of platform technologies.

3.2 Conceptual Model

My broad conceptual model is outlined in Figure 3.1 below. This model draws from both the resource based view (Barney, 1991; Wernerfelt, 1984) as well as evolutionary theory (Nelson

& Winter, 1982) to explain how resources influence a firm's capabilities. At a fundamental level, this model proposes that a firm can leverage its knowledge generating resources, defined and discussed later, in order to modify and enhance its routines. These modifications of routines can result in the enhancement of a firm's capabilities. Enhancement of the firm's capabilities may result in increased firm performance in comparison to the firm's competitors. Existing research argues that resources and routines are antecedents to a firm's capabilities. These relationships were discussed in Chapter Two to provide support for the basic conceptual model.

Figure 3.1: Overview of Knowledge Generating Resources, Routines, and Capabilities



This figure is identical to Figure 1.1

3.2.1 Limitations of the Conceptual Model

It is important to note that while the conceptual model proposes that routines are a mediator between knowledge generating resources and a firm's product development capabilities, this relationship will not be empirically tested. Many firms consider routines to be a key source of competitive advantage, and so they are generally unwilling to divulge them. This makes any meaningful empirical testing of the role of routines difficult. Consequently, the theoretical model that will be tested examines the relationships between different types of

experience and relational resources and a firm's product development capabilities. However, this dissertation does use the ideas of routines as a mechanism in which experience and relational resources influence the firm's product development capabilities in theory development.

3.3 How Knowledge Generating Resources Lead to Capability Development

I propose three mechanisms that managers engage in to enhance the firm's capabilities. First, managers assess the firm's capabilities and assess if those capabilities can achieve the firm's goals. Second, managers leverage the firm's knowledge generating resources which provide them with insights on how to design or alter routines to achieve the firm's goals. Third, managers implement those solutions by constructing new routines, or modifying existing routines, within the firm with the expectation that these routines will enhance the firm's capabilities.

3.3.1 Assessing Goals and Capabilities

Before managers within a firm take action with the firm's capabilities, they must have goals or desired outcomes that they hope to achieve with their actions. With regard to product development, a firm's managers may aspire to increase the effectiveness of the firm's product development capabilities, resulting in more desirable products, or may wish to increase the efficiency of the firm's product development capabilities, allowing the firm to design and develop products more quickly. These two goals are not mutually exclusive. Inherent in goal setting is a discrepancy between the state in which a firm or individual is in, and the state in which the firm or individual seeks to be. Social cognitive theory suggests that individuals engage in two processes with regards to goal setting and achievement (Bandura, 1986; Wood &

Bandura, 1989). The first process is discrepancy production, in which individuals set high goals for themselves. The second process is discrepancy reduction, in which individuals seek to diminish the discrepancy by exerting effort to achieve their goals.

These principles may be applicable at the firm level as well. Firms may elect to pursue difficult to reach goals. The firm must then assess whether or not they have the capabilities required to reach these goals. If they do not possess such capabilities, a discrepancy will exist between the firm's goal and their ability to achieve that goal. I propose that knowledge can be leveraged to increase the firm's capabilities.

Importantly, a firm's goal-making decision is not purely endogenous because if goals are easily achievable, competitors may also be able to imitate the firm, which would result in competitive parity (Barney, 1991). Firms must choose goals that will create a competitive advantage (Barney, 1991; Wernerfelt, 1984). Therefore, firms should set product development goals that not only create a unique and desirable product, but also enhance the firm's product development capabilities in ways that provide long term value to the firm.

3.3.2 Leveraging Knowledge

If managers perceive a discrepancy between the goals of the firm and the capabilities the firm has to achieve those goals, managers must create strategies to address the discrepancy. To create these strategies, I propose that managers leverage knowledge generating resources to improve their decision making abilities. Knowledge has been cited as a key resource that influences a firm's capabilities (Grant, 1996a,b; Foss, 1996; Kogut & Zander, 1992). Knowledge generating resources are defined in this dissertation as resources that allow a firm to gain new levels of understanding of phenomena through their accumulation and utilization. Knowledge

generating resources provide knowledge and unique understanding that can help a firm in creating or modifying its routines. Examples of resources that enhance a firm's knowledge include, but are not limited to, accumulated experience (Levitt & March 1988; Eggers, 2012; Nerkar & Roberts, 2004), human capital (Schultz, 1961; Becker, 1963), research and development (Graves & Langowitz, 1993), and relational resources (Dyer & Singh, 1998).

Knowledge generating resources differ from 'enabling resources' such as property and equipment. Enabling resources allow a firm to carry out its operations, such as the manufacturing of a product or the delivery of a service. However I argue that enabling resources do not, on their own, provide new knowledge that a firm's managers can leverage to modify their routines in order to enhance the firm's capabilities. Nevertheless, enabling resources may influence a firm's capabilities. Because enabling resources do not provide knowledge that helps a firm alter its routines, this dissertation does not explore their role in the enhancement of product development capabilities.

Managers can leverage the understanding provided by knowledge generating resources to design new routines, or design modifications to existing routines, to make the routines more effective. In this stage, managers evaluate many types of routines that they believe may accomplish the firm's goals. Throughout this process, managers recursively reflect on their knowledge base to better inform their routine selection decisions. Leveraging is similar to Eggers and Kaplan's (2013) process of routine *construction* which "addresses the ways in which cognition is implicated in the development and maintenance of routines which are the building blocks of capabilities" (p.296). However, leveraging differs from *construction* because construction places an emphasis on managerial cognition whereas leveraging emphasizes the utilization of knowledge resources to design, but not implement, routines and processes.

3.3.3 Implementation of Routines

Finally, managers must implement their new or modified routines in order to enhance the firm's capabilities. Given that routines are considered to be the source of competitive advantage in this dissertation as well as in evolutionary theory (Nelson & Winter, 1982), understanding the implementation of routines is an important part of understanding how managers influence the product development capabilities of a firm. This dissertation argues that routines can be improved upon influenced by the knowledge generating resources the firm has access to. The effectiveness of a firm's routines has been shown to be positively influenced by a firm's resources, including knowledge (Ray, Barney & Muhanna, 2004). The implementation process is similar to Eggers and Kaplan's (2013) process of *assembly* which suggests that multiple routines can be combined together to achieve an outcome. However, implementation *differs* from assembly because assembly involved the combination of multiple routines, whereas implementation may involve putting a single routine into action within a firm.

3.3.4 Mechanisms and Theory Development

As stated previously, this dissertation's focal industry develops complementary products for existing platform technologies. In my theory development I assume that individual firm goals are predetermined and therefore I do not develop theory regarding how a firm develops their goals. Therefore, my theory development focuses on both the *leveraging* and *implementation* processes: specifically how different types of experience and relational resource provide knowledge to firm managers, and how managers leverage that knowledge to design and implement routines that enhance the firm's product development capabilities.

3.4 Product Development Capabilities

I define product development capabilities as a firm's ability to achieve desired outcomes in its products or the processes used to create its products. As discussed in the literature review, two types of product development capabilities are important to firm performance and this dissertation focuses on these two specific product development capabilities: the effectiveness, as well as the efficiency, of a firm's product development capabilities.

I define the effectiveness of a firm's product development capabilities as the ability for a firm to develop highly desirable products. While 'desirable' is a subjective term, I use it to reflect the accumulated attractiveness of a product due to its features, attributes, utility, or value to the customer. Subjective definitions of product quality are commonly used in management research (Reeves & Bednar, 1994). Supporting the use of subjective indicators, Verona (1999) argued that product effectiveness is "related to fit with *market needs* and product quality" (p.134). In addition, Brown and Eisenhardt (1995) define their term, product concept effectiveness, as the "fit of the product with firm competencies and market needs" (p.366). Both of these definitions focus on the needs of the market, a subjective value. As discussed in the literature review, the effectiveness of a firm's product development capabilities is an important construct to study because product quality has been shown to lead to positive firm outcomes such as increased firm profitability and lower variance in profits (Kroll et al., 1999), price premiums (Buzzell & Gale, 1987; Kuzma & Shanklin, 1992), increases in sales and customer satisfaction (Tatikonda & Montoya-Weiss, 2001), as well as improved stock market performance (Hendricks & Singhal, 1996).

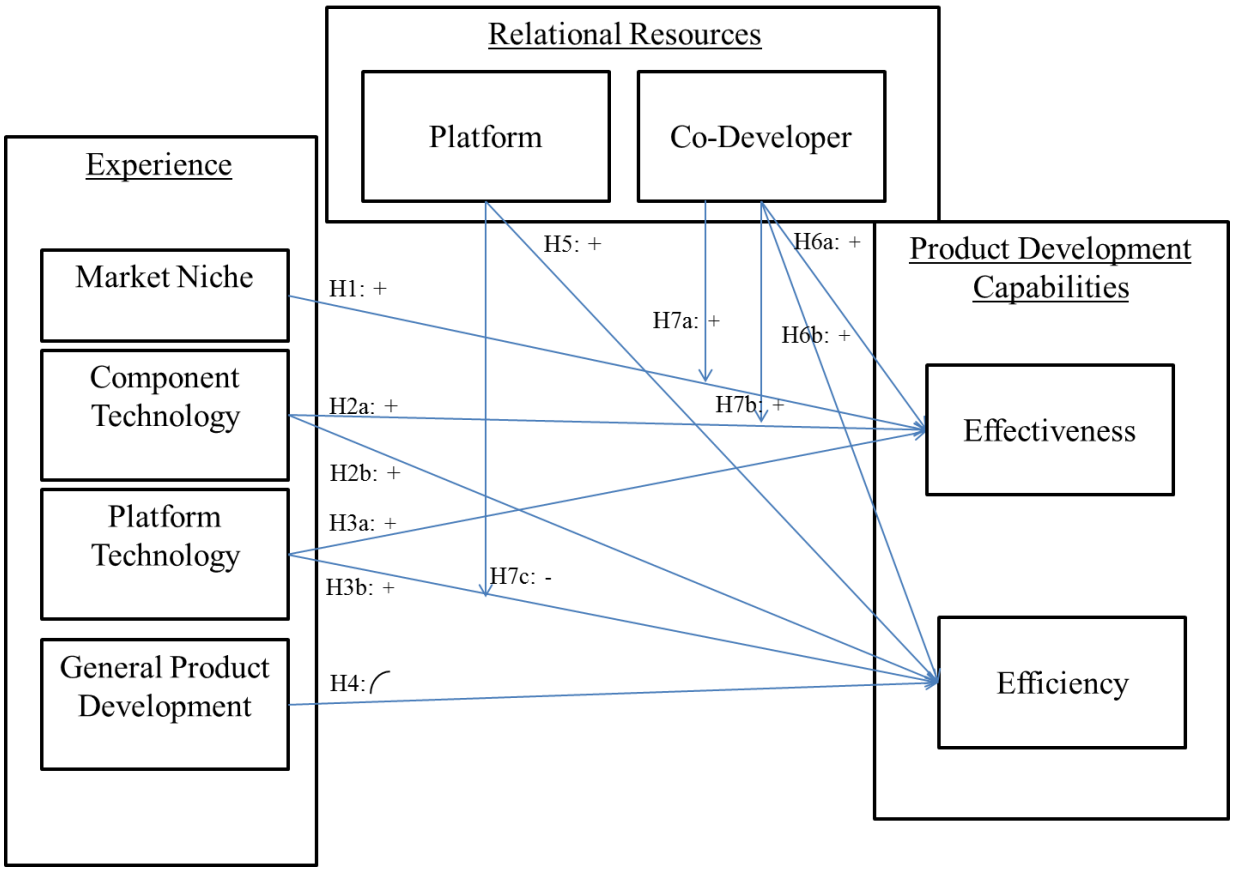
I define efficient product development capabilities as the ability for a firm to design and develop new products quickly. This capability has been defined similarly in two previous important studies. First, Brown and Eisenhardt (1995) refer to this capability as 'process performance' which refers to the "speed and productivity of product development" (p.366). In a review of the product development literature, Verona (1999) refers to this capability as 'process efficiency,' which he states is "measured in terms of lead time and productivity" (p.134). To recap the literature review discussion in Chapter Two, the speed in which a firm designs and develops new products is important because it allow a firm to be more nimble than its competitors, and therefore gives it a superior position within an industry (Dacko et al., 2008). Rapid product development may allow firms to gain a first mover advantage (Carpenter & Nakamoto, 1989; Lieberman & Montgomery, 1988; Kerin et al., 1992), or early entry to market, which have been shown to lead to gains in market share (Bowman & Gatignon, 1996; Robinson, 1988; Urban et al., 1986).

This dissertation proposes that experience and relational resources are knowledge generating resources that provide managers with information and understanding that allow them to enhance their firm's product development capabilities. These particular resources were selected because 1) I want to contrast the role of an internal and an external resource on a firm's product development capability, 2) opportunities to do so arise because of recent theoretical advancements regarding the role of experience on a firm's capabilities (Egger & Kaplan, 2013), and 3) firms increasingly need to develop partnerships with other firms to remain competitive in product development (Huston & Sakkab, 2006).

In the following sections, I propose that four types of experience and two different types of relational resources individually and jointly influence the effectiveness and efficiency of a

firm's product development capabilities. For future reference, these relationships are depicted in Figure 3.2 below.

Figure 3.2: Theoretical Model Depicting Hypothesized Relationships



3.5 The Role of Experience in Enhancing Product Development Capabilities

One important source of knowledge for the firm is its prior experience. Prior experience has been shown to enhance the development of a firm's capabilities by providing managers insight into which routines are effective and therefore used, and which are ineffective and should be modified (Lieberman, 1987; Arrow, 1962; Eggers, 2012; Eggers & Kaplan, 2013; Nelson & Winter, 1982). However, not all experience influences the development of a firm's capabilities equally. Recent studies have highlighted that the *type* of experience a firm has influences the

development of firm capabilities differently (Hoang & Rothaermel , 2010; Zollo & Reuer, 2010; Eggers, 2012). Therefore, to better understand the sources of product development capabilities it is important to delineate between different types of firm experience that can influence product development. I contend that four types of experience are particularly important to the development and enhancement of a firm's product development capabilities. These types of experience are (1) the firm's experience creating products for a specific market niche, (2) the firm's experience with components critical to its new products, (3) the firm's experience developing products for a technological platform, and (4) the firm's general history of product development experience. These four types of experience are not an exhaustive list of all types of experience that may provide a firm knowledge, but I consider these four types of experience to be critical to effective and efficient product development, and although they have been previously studied individually, they have not been investigated jointly. Further, within the context of complementary product development for platform technologies, not only is experience with different types of technologies important to the development of products, but market niche experience can also aid firms in delivering key product features that consumers desire.

Market niche experience is an important type of experience to understand because it provides firms with a unique understanding of their customer base. Component and platform experience are major types of technological experience a firm may have in product development. Technological experience has been contrasted with market experience in the past (Nerkar & Roberts, 2004), however, the study did not distinguish between different types of technological experience. Therefore, I believe a theoretical contribution can be achieved by explaining the separate effects of a firm's prior experience with components in its products and the firm's experience developing products for a platform. The reason for distinguishing between these two

types of experience is that firms can generally adapt to component innovations made by competitors, but struggle when the architecture (how the components interact) changes (Henderson & Clark, 1990). Different platforms have different architectures, so experience with a platform is a different type of knowledge than experience with components. Finally, while a firm's history of product development experience has been examined in the past (Lieberman, 1987; Arrow, 1962) it is important to examine the construct in conjunction with other types of experience (i.e., market, component, platform). Therefore, I argue that all four of these types of experience are important constructs to study and should be included in this dissertation. In the following sections I define each type of experience and explain how each type of experience influences a firm's product development capabilities.

3.5.1 Market Niche Experience

I define market niche experience as the depth of experience that a firm has developing products for a specific customer segment. Within the context of the videogame industry, a market niche is best represented by a game genre such as roleplaying games, shooting games, or racecar driving games. Market niche experience is a knowledge generating resource that provides a firm with information about successfully satisfying customer preferences. This information and experience may be important resources in designing highly desirable products. Recent research regarding market niche experience and product development capabilities found that focusing on one or a limited number of product niches had no effect on product quality, and also that the number of previous products in a niche had no effect on product quality, but that the number of concurrent products in a niche did have a positive effect on product quality (Eggers, 2012). While the study does use product quality as its dependent variable, it measures this

construct by evaluating the product's financial performance through a mutual fund's stock market performance compared to other funds over 36 months (Eggers, 2012). In addition, Nerkar and Roberts (2004) examined the effect of market experience on new product success and found that a firm's previous experience in a market closely related to a focal product innovation did not lead to increased product financial success for novel, non-generic, products.

While these studies stress the role of market niche experience, both studies utilize measures of financial performance as a measure of a product's quality. However, many external factors can obfuscate the relationship between market experience and financial performance. Further, the mechanisms through which market experience leads to product success are unclear. Nerkar and Roberts (2004) "suggest that proximal experience gives firms access to specific customers, established distribution channels, and area-specific reputations, all of which facilitate the introduction of new products into a particular area. At the same time, some of the assets that a firm needs are more general, and develop as a function of a broad portfolio of product-market experience" (p. 783). Such broad reasoning does not outline the exact mechanisms through which market experience improve a firm's product development capabilities. Therefore, I propose and examine key mechanisms through which market experience influences a firm's product development capabilities.

I claim that the depth of a firm's experience in a market niche will increase the effectiveness of the firm's product development capabilities because it provides the firm with knowledge it can leverage in designing or implementing routines. There are different types of knowledge that market niche experience provides. First, experience with products in a particular niche provides the firm knowledge of the features customers do and do not desire (Powell, 1995; Dougherty, 1990; Cooper 1979). This knowledge can be utilized to incorporate preferred product

features into subsequent products. For example, in the video game industry, a firm that makes football games will gain knowledge of the features of football games that consumers do and do not desire. Additionally, previous work in a market niche may provide product developers with ideas for new product features that they were unable to include in previous product iterations. A case study involving Medtronic, a medical products firm, highlights how some product ideas are shelved until subsequent products are designed (Christensen, 1997). These ideas can be refined over time to add significant value to future product iterations. Lastly, experience in a product niche may provide the product developers knowledge of how to modify *existing* product features to make the overall product more desirable, a form of incremental innovation (Schilling, 2010).

Recall that a routine "may refer to a repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational individual performance" (Nelson & Winter, 1982, p.97). The firm can then take knowledge of routines used in prior market niche experiences and leverage that knowledge in the design and modification of future routines with the goal of developing highly desirable products. An example of this is when a software product manager elects to use an agile software development process (Beck et al., 2001). Agile software development forces a product manager to choose specific product features that they believe will be most important to customers. Then the engineering team determines which of those product features they can include in the product within their development schedule. Once these features are agreed upon, the product manager is not allowed to change the requirements and the engineers are accountable for including those features in the product by the product's release deadline. The effectiveness of an agile product development process, a routine, is enhanced by prior market niche experience because the experience provides the product manager knowledge of the market's needs. This knowledge

allows the product manager to modify the routines the firm uses, either by modifying its current agile development process or establishing a new agile development process, to increase the effectiveness of the firm's product development capabilities. Given these arguments, I contend that the depth of a firm's previous experience in a product niche will increase the *effectiveness* of the firm's product development capabilities when producing products in that niche.

Hypothesis 1: The greater the firm's depth of experience in a product niche, the higher the effectiveness of the firm's product development capabilities in that market niche.

3.5.2 Technological Experience

As presented in the literature review, technological experience and product success have been studied in the past. Nerkar and Roberts (2004) used patent data to determine that experience close to the focal product innovation aided the product's financial success. However, I contend it is important to distinguish whether the firm's technological experience is with the components of a product or with the architecture of a platform the firm is developing a product for. Recall that platforms represent a technology architecture that firms can develop complementary products for. It has been shown that firms tend to adapt to component innovations in an industry more easily than architectural innovations (Henderson & Clark, 1990). Therefore, the knowledge firms gain from experience with components and from experience with platforms may influence their product development capabilities differently. In addition, it is important to delineate between the desirability of a product and its financial success due to non-technical factors, such as marketing capabilities, that can obfuscate the relationship between product quality and financial success. Therefore, in order to strengthen this dissertation's theoretical contributions, I delineate between

a firm's experience in components and its experience in developing products for a platform's architecture. Further, I explain how these two types of experience influence both the effectiveness and efficiency of a firm's product development capabilities.

3.5.2.1 Component Experience

The components of a product aggregate to create the entire product (Henderson & Clark, 1990). I define component experience as the depth of experience a firm has using critical components in the focal product. Firms will often reuse components in future iterations of a product. In videogame development, 'middleware' is a good example of a component. Middleware is software that aids in the development of a product. An example of middleware in the videogame industry would be a product called SpeedTree. This product works with other components in a product, such as the game's engine, and the platform the game is being developed for, and quickly places trees within a game's environment (SpeedTree, 2013).

Component experience provides two different types of knowledge to product managers. First, previous experience with components provides knowledge that familiarizes product developers with the abilities of the component (Henderson & Cockburn, 1994; Leonard-Barton, 1992). This knowledge may allow the engineers to push the component's abilities to new limits in subsequent products (Bhaskaran & Krishnan, 2009). The new performance abilities of the component may provide users with increased utility and make the focal product more desirable. Second, the firm's knowledge of its critical components will enhance its ability to have the critical components work with other components within the product's architecture. This knowledge may decrease the amount and severity of defects or errors that occur in the final product. Fewer errors in the final product will decrease an end users' dissatisfaction caused by components that do not interact well together.

The knowledge provided by component experience may be *leveraged* by a firm to modify and enhance its routines. For instance, knowledge gained from component experience may better inform product managers of when they should switch to new component technologies. Literature on technology S-curves suggests that older technologies are often replaced by more effective technologies throughout history (Christensen, 1992). A firm with accumulated experience with a component's technology may be better able to implement routines that allow the firm to foresee when that component's technology will no longer be useful. These routines may also enable the firm to more easily switch to more effective components in the future. Therefore, component experience provides knowledge that a firm's managers can leverage to improve their routines which will enhance the effectiveness of the firm's product development capabilities. For these reasons, I believe that the firm's experience with critical components will increase the effectiveness of the firm's product development capabilities.

> *Hypothesis 2a: The greater the firm's depth of experience with critical component technologies, the higher the effectiveness of the firm's product development capabilities will be when using those components in future products.*

I further argue that component experience provides knowledge that can be leveraged to positively influence the *efficiency* of a firm's product development capabilities. In fast paced and complex product development situations such as software programming (Brown & Eisenhardt, 1995), programming code from a previous product can often be re-used in a new product with only minor modifications (Gao, Tsao & Wu, 2003). Programming code is a form of codified knowledge. Managers can *leverage* this knowledge by implementing routines to reuse code

whenever possible in order to save time in product development. Additionally, if product developers already know how a component works from previous experience with it, they do not need to re-learn how the component operates within a product's architecture (Henderson & Clark, 1990). This will save additional product development time. Previous experience with critical components may generate explicit codified knowledge, such as manuals and 'how-to' documents. These documents can help new product developers to more quickly understand how the firm's critical components work both independently and in combination with other components in the product. Research has shown that high quality documents increase the efficiency of product development (Haas & Hansen, 2007).

The knowledge derived from component experience can be *leveraged* by firms to make their product development capabilities more efficient. Prior component experience can aid a firm when reusing old components in new products. When a firm is reusing components, the firm will already have established routines to obtain those components. The firm can quickly reuse these routines to increase the speed of product development, or the firm will have knowledge it can leverage on how to modify these routines to obtain components more quickly. Furthermore, knowledge gained from prior component experience can help managers improve the routines used to select suppliers, further increasing the efficiency of firm's product development capabilities. Therefore, I contend that experience with critical components within a product will enhance the efficiency of a firm's product development capabilities.

Hypothesis 2b: The greater the firm's depth of experience with critical component technologies, the higher the efficiency of the firm's product development capabilities when using those components in future products will be.

3.5.2.2 Platform Experience

Technology platform architectures "lay out how all the components will work together" (Henderson & Clark, 1990, p. 2). Platform architectures support the development of iterations of the platform or of complementary products compatible with that architecture (Zhu & Iansiti, 2012). For example, the Windows operating system has software components within it, but Windows' architecture allows third parties to develop products that work on the Windows platform. I define platform experience as the depth of experience a firm has developing complementary products for a specific platform. An example would be the large number of products Adobe has created for the Windows platform.

Prior platform experience also provides knowledge that product managers can *leverage* to modify the firm's routines. First, previous experience developing products for a platform should provide the focal firm's engineers with knowledge of the platform's capabilities (Henderson & Clark, 1990). Product developers can *leverage* this knowledge by developing routines that more fully exploit platform capabilities. The resulting improvements in product capabilities should provide customers more utility, increasing product desirability. Second, experience developing products for a platform's architecture provides knowledge of the platform's syntaxes and rules (Henderson & Clark, 1990). This knowledge could be leveraged by instituting routines that will reduce the number of defects or errors that would detract from the quality of the firm's product. Third, prior platform experience can provide product managers with knowledge of the most difficult aspects of development for that technology. The product manager can *leverage* this knowledge to design and implement routines to overcome the development hurdles a platform may have. For instance, in game development, early versions of the PlayStation 2 platform often caused problems for game developers because the syntaxes and rules of the platform were not well defined. This caused early versions of a game to not work on the platform during the game's

development. However, product managers were able to overcome these hurdles by putting into place routines that assigned people with unique knowledge of the platform to perform the most critical tasks of product development (Gertsmann, 2014). Thus, prior platform knowledge can influence the product development routines of a firm, allowing the firm to create more desirable products with fewer errors. For these reasons, I contend that the more experience a firm has developing products for a platform, the more *effective* the firm's product development capabilities will be.

> *Hypothesis 3a: The greater the firm's depth of experience in developing products for a platform, the higher the effectiveness of the firm's product development capabilities will be when developing future products for that platform.*

In addition, a firm's platform experience will increase the *efficiency* of the firm's product development capabilities when it develops future products for that platform. First, previous experience developing products for a platform provides engineers with explicit knowledge of the platform's rules and syntaxes (Henderson & Clark, 1990). The knowledge of these rules and syntax can be leveraged because they do not need to be relearned, which will save time in future product development for that platform. Second, previous experience with the platform will provide the engineers knowledge of how components interact with the platform's architecture (Henderson & Cockburn, 1994). Product developers can leverage this understanding of the platform to reduce the number of defects or errors in the product. In developing the previous hypothesis, I argued that defects detract from the desirability of a product. Since this motivates firms to try to eliminate defects before a product is released, when there are fewer defects in a

product due to platform experience, this will reduce the amount of time needed to fix those errors, which will save additional time in product development. In addition, product managers can leverage prior platform knowledge to modify their routines or implement new routines to make their product development capabilities more efficient. For example, platform owners generally require complementary products to conform to quality assurance standards. Videogames developed for platforms such as the Xbox or PlayStation systems are tested to make sure they are useable on those platforms before they can be released to the public. If a firm has gone through this process with previous products, they will know what the platform owner is looking for in quality assurance, and will be able to meet those requirements. This knowledge will help product managers in developing routines that ensure their products meet the quality assurance criteria on the first attempt, thus saving time in the product development process. For these reasons, I propose that platform experience will enhance the *efficiency* of a firm's product development capabilities.

> *Hypothesis 3b: The greater the firm's depth of experience in developing products for a platform technology, the higher the efficiency of the firm's product development capabilities will be when developing subsequent products for that platform.*

3.5.3 General Product Development Experience

I define general product development experience as the depth of experience a firm has in developing any type of product in their industry. This is a broad type of experience that has been shown to lead to productivity gains (Arrow, 1962; Lieberman, 1987). The general finding is that repeated product development activity creates routines within a firm which become more

efficient over time (Nelson & Winter, 1982). These routines may involve how different departments interact with each other during product development. Repeated iterations of product development make communication and expectations between departments more clear. Increased clarity in communications and documents has been shown to make project teams more productive (Haas & Hansen, 2007). If communication does not become clearer, managers will replace or modify inefficient routines (Nelson & Winter, 1982).

A host of early studies have found learning curve effects in production and manufacturing (Argote, 1993; Hatch & Mowery, 1998; Schilling et al., 2003; Yelle, 1979). It is important to include this broad type of product development experience in my model for two reasons. First, I wish to account for other types of experience than market niche, component, and platform experience which may provide gains in product development capabilities. Including this broad type of experience in my model will provide product development scholars with insights on how much variance in product development capabilities is explained by the other three types of experience I investigate. Second, I propose that the relationship between general product development experience and the *efficiency* of a firm's product development capabilities demonstrates a *curvilinear* shape. Specifically, I propose there are diminishing returns to general product development experience. This can happen for two reasons: first, with each new iteration of a product, less new knowledge is gained from the product development cycle. This occurs because the majority of product development lessons are learned early on in a firm's product development history. Knowledge created by subsequent product development cycles may be redundant. In addition, other knowledge generating resources, such as R&D, have already been shown to provide diminishing returns to knowledge creation (Rothaermel & Hess, 2007). If the knowledge created from R&D acts in a similar way to the knowledge created from broad product

development experience, I expect it to also provide diminishing returns. Therefore, I propose that general product development experience will enhance the *efficiency* of a firm's product development capabilities, but there will be diminishing returns from experience.

Hypothesis 4: The greater the firm's depth of experience in general product development, the higher the efficiency of the firm's product development capabilities when developing future product; however this relationship will display a non-linear relationship with increasing levels of experience resulting in progressively smaller returns.

3.6 The Role of Relational Resources in Enhancing Product Development Capabilities

The relational view discussed in Chapter Two contends that firms can gain a competitive advantage due to accessing resources of their partners (Dyer & Singh, 1998). One important resource that firms may gain from other firms is knowledge through knowledge sharing activities (Dyer & Singh, 1998). Therefore, relational resources can enhance a firm's product development capabilities as a knowledge generating resource. Two ways in which this knowledge is transferred are through human co-specialization and partner specific absorptive capacity (Dyer & Singh, 1998; Lane & Lubatkin, 1998).

Human co-specialization is a concept developed by Dyer and Singh (1998), but builds from Williamson's idea of human asset specificity (1985). Human co-specialization "increases as alliance partners develop experience working together and accumulate specialized information, language, and know-how. This allows them to communicate efficiently and effectively, which reduces communication errors, thereby enhancing quality and increasing speed to market" (Dyer

& Singh, 1998, p.662). Therefore, employees working at two firms that have a relationship with each other will develop communication and knowledge sharing routines that can influence the product development capabilities of each firm. In addition, partner specific absorptive capacity plays an important role in knowledge transfer between firms. Building from Cohen and Levinthal's (1990) construct of absorptive capacity, partner specific absorptive capacity is limited to examining the factors which influence knowledge transfer between two specific partner firms (Dyer & Singh, 1998). This is similar to 'relative absorptive capacity' (Lane & Lubatkin, 1998). Two factors that influence knowledge transfer between firms are the development of routines that increase "the frequency and intensity of sociotechnical interactions" and the extent to which the two firms have corresponding knowledge (Dyer & Singh, 1998, p.665). Therefore, knowledge sharing between two firms influences both firms' product development capabilities.

However, not all relationships provide the same types of knowledge. Therefore, the *type* of relationship a firm has is important implications which product development capabilities become enhanced. It is possible, for example, that the relationship a firm has with a platform owner may enhance the *efficiency* of the firm's product development capabilities, but the relationship may not aid the *effectiveness* of those capabilities. Furthermore, the relationships a firm has with co-developers are different from the platform owner relationship, and the *efficiency* and the *effectiveness* of the firm's product development capabilities may not be impacted by those relationships in the same ways. I review each type of relationship individually and make my arguments below.

3.6.1 Platform Relational Resources

I conceptualize platform relational resources as an agreement for a focal firm to develop products exclusively for a platform owner. This type of relationship can be established in two ways. First, some firms that develop complementary products for a platform are a subsidiary of the platform owner. For example, Microsoft, which is the owner of the Xbox videogame platform, owns several studios that make games specifically for the Xbox. The second way this relationship can be established is through an alliance. Many times a platform owner will form alliances with firms to produce complementary products exclusively for its platform. For example, Microsoft has agreements with firms to make complementary products only for the Xbox platform. These firms are often referred to as 'first party developers' because they are independent firms but they are in an alliance to develop products for only one platform. Recent research has examined the relationship between platform owners and firms that develop complementary products for the platform (Gnyawali, et al., 2010). However, Gnyawali et al., (2010) examined firm performance outcomes that accrued to the platform owner from establishing relationships with complementary product developers. This dissertation, on the other hand, examines other types of benefits complementary product developers derive from their relationship with platform owners.

I argue that firms that have a relationship with a platform owner will have more *efficient* product development capabilities. This occurs because the platform owner perceives less risk in revealing critical information to its subsidiaries and first party developers (Lavie, 2006). Subsidiaries and first party firms have no interest in using proprietary platform information for nefarious purposes, since doing so would primarily hurt the complementary product producer because they are dependent on the stability and growth of the platform they develop products for.

Therefore, the relationship between the platform owner and their subsidiaries or first party developers will exhibit increased knowledge sharing (Dyer & Singh, 1998; Lavie, 2006).

This increased level of knowledge sharing enjoyed by firms that have formal relationships with platform owners will provide the firm with two important types of knowledge they can leverage to make their product development capabilities more *efficient*. First, the firm may be privy to knowledge of the 'inner workings' of the platform technology that is not available to other complementary product developers without those critical platform owner relationships. This knowledge can be leveraged by the firm to implement routines to exploit those internal platform processes. These routines may allow the firm to produce new products at a faster rate than its competitors. Second, recall that trust is very important in obtaining rents through relationships (Zaheer, McEvily & Perrone, 1998; Perrone, Zaheer & McEvily, 2003). Subsidiaries and first party developers may receive new platform-specific information sooner than other developers due to relationship trust. This information may allow the developer to alter routines before competing firms, and give the firm a head start in developing new products. This type of information sharing may occur when the platform owner is developing a newer platform, such as going from PlayStation 3 to PlayStation 4. The platform owner needs complementary products ready for the launch of the new platform, but the platform owner may want to contain the technical details of the new platform to firms they trust. Related to routines, the efficiency of the focal firm's product development capabilities may be increased because the platform owner may alter its own routines to 'fast track' the quality assurance process for products developed by subsidiaries and first party firms. A platform owner may alter its routines because these products are exclusive to the platform, which may motivate consumers to purchase the platform in order to use the exclusive product. Therefore, the platform owner is more motivated to get the

exclusive product through quality assurance and onto store shelves than they are for non-exclusive products. Because an alliance with a platform owner provides increased knowledge sharing, and new knowledge aids firms in modifying their routines, I believe that when a firm has a relationship with the owner of a platform that they are developing products for, the efficiency of the focal firm's product development capabilities will be increased.

> *Hypothesis 5: When a firm has a structured relationship with a platform owner to only produce products for that platform, the efficiency of the firm's product development capabilities will be higher than those of a firm without a relationship with the platform owner.*

3.6.2 Co-Developer Relational Resources

Co-developer relational resources refer to the depth and breadth of a focal firm's relationships with other firms that make technologies, components, or assets for the focal firm's products. Many times a producer of complementary products will collaborate with other firms to develop components for their products. While these situations may pose interesting questions regarding the boundaries of the firm (Coase, 1937; Williamson, 1985), the focus of this dissertation is on whether the relationships a focal firm has with co-developers influences the firm's product development capabilities to enhance competitive advantage. I propose that the breadth of co-developer relationships (i.e., number of co-developers) will increase the *effectiveness* of the focal firm's product development capabilities and the depth (i.e., duration) of the firm's experience with their co-developers will influence the *efficiency* of the focal firm's product development capabilities.

The use of multiple co-developers will increase the *effectiveness* of the focal firm's product development capabilities for several reasons. Firms will engage co-developers in production because co-developers tend to specialize in making certain components and are generally more capable in certain aspects of product development than the focal firm. By working with a co-developer, the focal firm can *leverage* the co-developer's specialized knowledge and skills in those areas of product development. A firm can also implement routines to work with co-developers when the focal firm's knowledge of an area of product development is lacking. If a firm already has particular specialized skills and knowledge, they would not need to collaborate with the co-developer during product development. The focal firm would instead be able to develop the product on its own, appropriating the equity or cash it would have given to the co-developer for itself. Therefore, a firm's use of a co-developer should indicate that the co-developer can produce components of higher quality than the focal firm is able to, which should result in a final product of higher effectiveness. This argument is similar to Dyer and Singh's (1998) third source of relational rents, complementary resource endowments, which suggest a synergy between resources of the focal developer and its co-developers. Relatedly, co-developers should be motivated to produce high quality products for the focal firm for two reasons. First, the co-developer may obtain prestige or recognition through the creation of components for the focal firm's product (Nahapiet & Ghoshal, 1998). Second, co-developers are motivated to produce components of high quality in order to secure future contracts, which results in rents for the co-developer. For these reasons, I contend that the more co-developers a focal firm engages to make components and technologies for their products, the more *effective* the focal firm's product development capabilities will be.

Hypothesis 6a: The greater the breadth of co-developers a focal firm works with on a product, the higher the effectiveness of the firm's product development capabilities will be.

I argue that the experience a focal firm has with its co-developers will also influence the *efficiency* of the focal firm's product development capabilities. Specifically, the longer the history between the focal firm and their co-developer, the more efficient the focal firm's product development capabilities will be. This will occur because as the focal firm and co-developer work together on products over time, inter-firm knowledge sharing routines will be developed through human co-specialization (Williamson, 1985; Dyer & Singh, 1998). These *routines* will aid the efficiency of product development for three reasons. First, given a long history of working with the focal firm, the co-developer will have knowledge of what the focal firm expects from the co-developers' components. The co-developer can leverage this understanding to develop routines that allow it to quickly meet the focal firm's needs. These routines may reduce the number of times the co-developer will need to refine components in order to meet the focal firm's expectations. Second, the focal firm will have experience working with the co-developers' products. This experience provides knowledge that allows the focal firm to refine the routines it uses with its co-developers and will therefore be able to more quickly integrate the co-developers' components into the final product. Additionally, a history of working with a co-developer leads to the focal firm trusting the quality of the components the co-developer provides (Shapiro, 1983). This trust means that the focal firm will be less likely to seek out different co-developers, and the focal firm will more quickly work with the co-developer with whom they have already established a relationship. This reduces the amount of time the focal

firm spends developing routines to vet co-developers, and therefore increases the efficiency of the focal firm's product development capabilities. As a result of these three reasons, I propose that a longer history between a focal firm and a co-developer will increase the efficiency of a focal firm's product development capabilities.

Hypothesis 6b: The longer the focal firm's history with co-developers, the higher the efficiency of the firm's product development capabilities when developing products with those co-developers.

3.7 The Interactive Effects of Relational Resources and Experience on Product Development Capabilities

Understanding the direct effects of different *types* of experience and relational resources on product development capabilities is important. However, it is more theoretically interesting to understand the interplay and interaction of experience and relational resources on a firm's product development capabilities. It is important to understand these interactive effects because different combinations of experience and relational resources may drive, or hinder, a firm's product development capabilities in ways that each resource cannot do on its own. This section proposes three types of interaction effects between different types of experience and relational resources that I believe will have the greatest effect on a firm's product development capabilities. First, I argue that there is a *complementary* effect between the firm's experience in a specific market niche and the history a focal firm has with its co-developers on *effectiveness* of the firm's product development capabilities. Second, I propose that there is a *complementary* effect between the history a focal firm has with its co-developers and the focal firm's experience with

the co-developer provided critical components on the *effectiveness* of the firm's product development capabilities. Third, I put forth that there will be a *substitution* effect between the depth of experience a firm has developing products for a platform and the firm's relationship with a platform owner on the *efficiency* of the firm's product development capabilities.

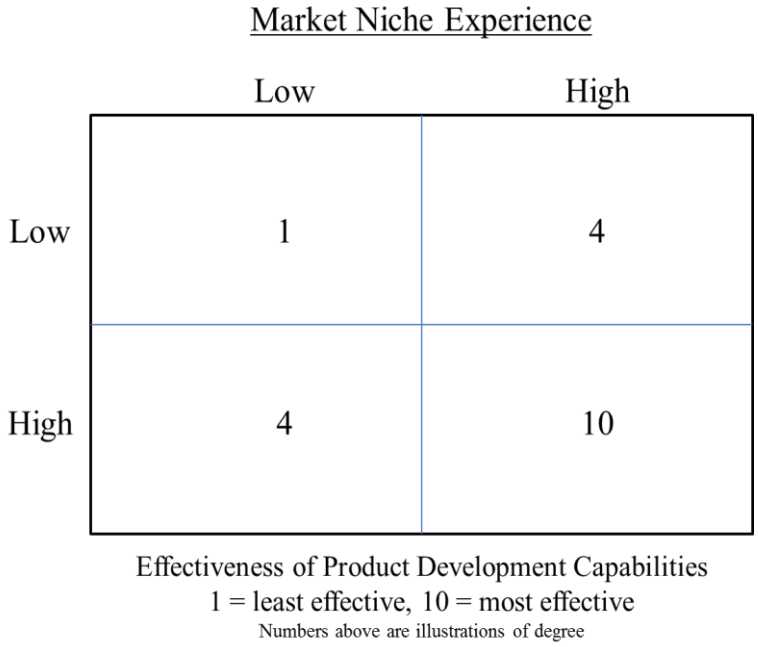
3.7.1 Complementary Effects Between Co-developer Relationship Depth and Market Niche Experience

My first interaction hypothesis is that there will be a *complementary* effect between the depth of the relationship a focal firm has with its co-developers and the amount of experience a firm has in a market niche on the *effectiveness* of the focal firm's product development capabilities. I argue that market experience provides knowledge which may be difficult to transfer explicitly to co-developers. However, the more experience a firm has developing products in a market, the easier it will be for the firm to implement routines that address the consumer desires they are attempting to satisfy. In addition, the longer a firm has been working with a co-developer, the lower communication barriers become due to human co-specialization (Williamson, 1985; Dyer & Singh, 1998) and the establishment of communication routines between the firms. This allows the focal firm to more accurately convey, and the co-developer to understand, what the focal firm expects from the co-developer's components. This interaction will result in two outcomes which should increase the *effectiveness* of the focal firm's product development capabilities. First, this increased knowledge of the market niche and communication routines between the focal firm and the co-developer should result in higher quality components from the co-developer that will meet the market's needs in a superior manner. Second, since the co-developer has worked for the focal firm often in a specific market niche, the co-developer should have skills and routines to make components that are specific to that market. Therefore, I expect the components developed by the co-developer to be more

effective. In sum, the arguments above suggest that the history between a focal firm and its co-developers interact positively with the focal firm's experience in a market niche to have a complementary effect on the *effectiveness* of the focal firm's product development capabilities.

Hypothesis 7a: The relationship between market niche experience and the effectiveness of a firm's product development capabilities is moderated by the depth of relationship the firm has with its co-developers, such that when market niche experience is high and experience with co-developers is high, the effectiveness of the firm's product development capabilities will be at its highest.

Figure 3.3: Market Niche Experience and Co-Developer Experience Interaction



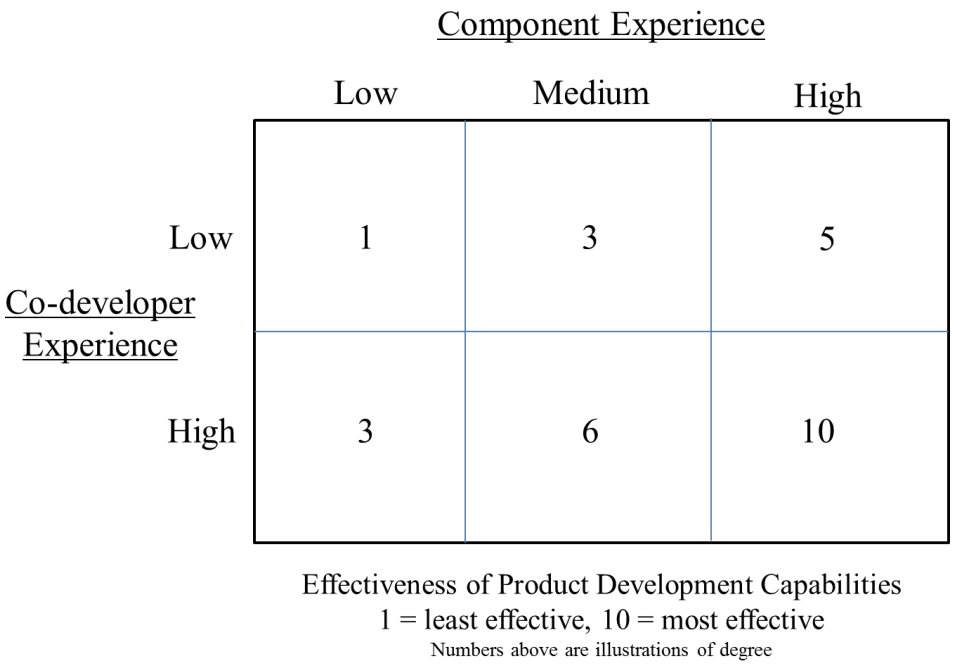
3.7.2 Complementary Effects Between Co-developer Relationship Depth and Component Technology Experience

Second, I propose that there will be an interactive effect between the depth of experience a focal firm has working with its co-developers and the focal firm's experience with the critical

component technologies in its product. Specifically, the history the focal firm has with its co-developers will *complement* the experience the focal firm has with critical components within its product on the *effectiveness* of the firm's product development capabilities. I contend that this interaction will occur for two reasons. First, the more experience the firm has with components critical to its product, and the longer the firm has been working with its co-developers, the more effective the routines the focal firm uses to communicate with its co-developer regarding components. These advanced communication routines may be used to instruct the co-developer how to create components so that the components will interact well with other components in the product due to human co-specialization (Dyer & Singh, 1998). Providing unclear instructions to co-developers was shown to complicate and delay production processes when Motorola attempted to automate their production of pagers (Gill & Wheelwright, 1997). Therefore, providing clear instructions and having partner specific absorptive capacity will reduce the number of errors or defects the product has, which would make the focal firm's end product more desirable. Second, there may be synergistic effects on the focal firm's product when the focal firm has knowledge of its critical components and an established co-developer is providing superior quality components. For example, combining Nypro's extensive knowledge of molding technologies and components and their history of extensive work with Johnson and Johnson, the two firms were able to produce disposable contact lenses that met manufacturing tolerances never before achievable by other firms (Christensen, 1993). This suggests that experience with critical technologies and an extensive working history can be *leveraged* to design advanced co-development routines that lead to enhanced product development capabilities.

Hypothesis 7b: The relationship between component experience and the effectiveness of a firm's product development capabilities is moderated by the depth of relationship the firm has with its co-developers, such that when component experience is high and experience with co-developers is high, the effectiveness of the firm's product development capabilities will be at its highest.

Figure 3.4: Component Experience and Co-developer Experience Interaction



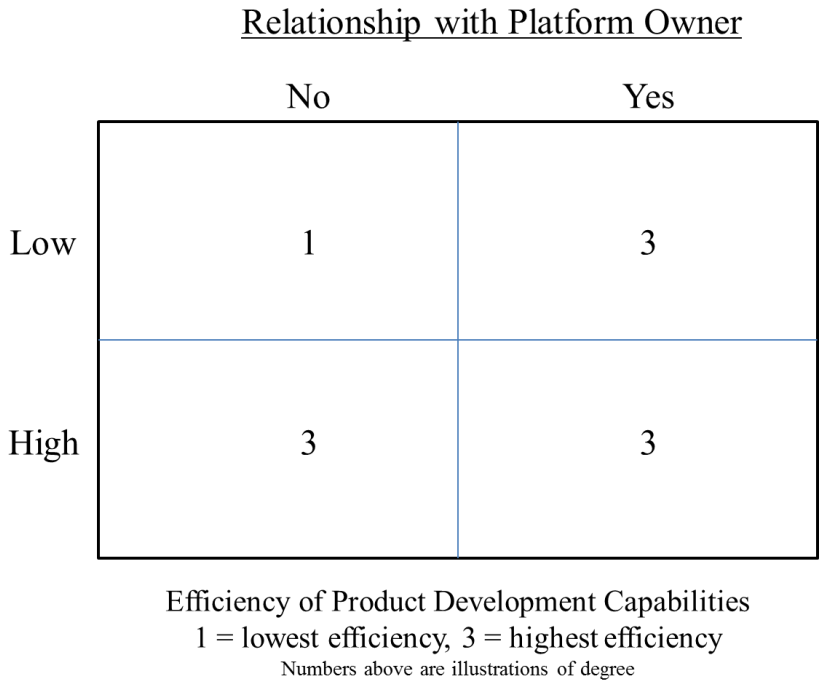
3.7.3 Substitution Effects Between Platform Developer Relationship and Platform Development Experience

The third interaction I propose is a substitution effect between the focal firm's relationship with a platform developer and the experience that firm has developing products for the platform. Earlier, I argued that a relationship with a platform developer will provide a firm with efficiency benefits due to knowledge transfer through human co-specialization (Dyer & Singh, 1998; Williamson, 1985). However, knowledge gained from experience developing

products for a platform may be redundant to knowledge gained directly from a relationship with the platform owner. Redundant knowledge will not aid product development teams (Hansen, 1999). Second, firms that do not have a relationship with the platform owner may be able to obtain the benefits of this knowledge through experience developing for the platform. In this case, firms that have a relationship with a platform owner and firms that have experience with the platform itself both have similar knowledge they can both *leverage* in implementing efficient product development routines. Therefore, I believe that there will be a substitution effect between the relationship a firm has with a platform owner and the experience the firm has developing products for that platform on the efficiency of the focal firm's product development capabilities.

> *Proposition 7c: The relationship between platform experience and the efficiency of a firm's product development capabilities is moderated by the relationship the firm has with platform owners, such that when platform experience is high the relationship with platform owners will not increase the efficiency of the firm's product development capabilities.*

Figure 3.5: Platform Relationship and Platform Experience Interaction



3.8 Conclusion

This chapter has presented and explained my arguments as to why different types of experience, and different types of relational resources, will individually and jointly influence two types of product development capabilities: effectiveness and efficiency. The hypotheses are illustrated in Figure 3.2 and I have summarized the arguments regarding the knowledge obtained and how it could be leveraged and implemented in each hypothesis in Table 3.1 below. The remainder of this dissertation empirically tests the hypotheses developed in this chapter. The testing methodology will be detailed in Chapter Four, followed by testing results in Chapter Five and, finally, a discussion of those results in the final chapter.

Table 3.1: Summary of How Knowledge is Leveraged to Design and Implement Routines

Hypothesis	Knowledge Obtained	How Knowledge is Leveraged & Routines are Implemented
H1: Market Experience on Effectiveness	Knowledge of customer desires providing insight to managers on which product features to prioritize	Managers may alter product development practices such as adopting agile development
H2a: Component Experience on Effectiveness	Knowledge of component to improve its use in focal product	Routines may be developed that encourage a firm to switch to new components to maintain product desirability
H2b: Component Experience on Efficiency	Knowledge of component to quickly reuse the component in product development	Modification of routines to obtain critical components logistically quickly
H3a: Platform Experience on Effectiveness	Knowledge of the platform's capabilities and what types of products, and product features, can be developed on the platform	Plan routines involving which departments or employees are most capable at certain aspects of production
H3b: Platform Experience on Efficiency	Knowledge of platform's rule and syntaxes do not need to be relearned	Adjust routines to quickly get through platform owner's quality assurance process
H4: General Product Development Experience on Efficiency	Knowledge of which product development processes worked well and which did not in prior development cycles	Modification of prior routines that are perceived to have hindered success
H5: Relationship with Platform Owner on Efficiency	Gain knowledge of the platform's inner workings or of new platform versions before competitors	Implement routines to exploit unique knowledge or implement these routines earlier than competitors
H6a: Breadth of Relationships on Effectiveness	Access to co-developers knowledge and specialized skill in an area of product development	Develop routines to work with co-developers when the focal firm lacks knowledge in an area of product development
H6b: Depth of Relationships on Efficiency	Knowledge of how to best instruct co-developers on who to create and submit components for focal product	Develop routines to manage co-developers to streamline production
H7b: Complementary Effect of Component Experience and Depth of Relationships on Effectiveness	Managers gain knowledge of how the components should operate within the product's architecture as well as knowledge of their co-developers routines and abilities	Managers in the focal firm can alter the processes they utilize to instruct co-developers on the components the focal product requires and how those components need to work with other components

4.0 METHODOLOGY

4.1 Introduction

This chapter details the methodology I use to collect data to test the hypotheses outlined in the previous chapter. I detail the sources and types of data I collect, how I measure constructs, and the analyses I conduct. I first describe my sample, then discuss my dependent variables, followed by my independent and control variables. In section 4.6, I describe the statistical analyses I perform on this data. Finally, I include descriptions of additional analyses that, although they do not directly test the hypotheses in this dissertation, help to validate its findings.

4.2 Sample and Methodological Approach

An ideal sample must include multiple characteristics in order to best test the hypotheses detailed in Chapter Three. Given that this dissertation relates to product development capabilities, the product sample group must have an established and consistent metric for quality and include information to be able to determine development time. Second, the sample industry must develop products for platform technologies. Third, given that my independent variables are firm level characteristics, I require a large sample of heterogeneous firms. Fourth, I need to be able to accurately determine whether a firm co-develops a product with other firms, and be able to identify those other firms. Lastly, I must able to obtain accurate information regarding the prior experience each firm has had in product development.

I selected the video game development industry as the data source for this dissertation. The video game development industry primarily includes three types of firms: platform owners, game development studios, and publishers. Platform owners develop, own, and promote gaming platforms. Examples include Sony and its PlayStation platform and Microsoft and their Xbox

platform. Sony and Microsoft promote their gaming platform hardware in order to increase user adoption. Game development studios create game software for these gaming platforms. Finally, there are game publishers. These firms provide the financial support game development studios need to create a game in return for the rights to sell the game to brick and mortar and online vendors. Some very large publishing firms, such as Electronic Arts, Activision, and Ubisoft own their own game development studios, allowing them to control the intellectual property the studio produces. This intellectual property can be highly valuable if an initial game is a success and a series is created based on the game's characters, world, or story.

There are several reasons why the videogame development industry is an ideal setting for this dissertation. First, videogames have an established metric of quality, a MetaCritic score, which I describe in more depth in section 4.3.1. Second, each game includes credits, similar to those at the end of movies, which provide several key pieces of information. Identifying the leaders of the project allows me to estimate the time it took a game to be produced, by determining the length of time between game releases by specific director or producer. Game credits list the co-developers the focal firm engaged in the product's development, identifying key relationships. A third reason this industry is ideal for this dissertation is that there are a large number of firms that develop products for gaming platforms, which provides a heterogeneous sample of firms of all sizes and experience. Publicly available information on each game studio's previous products allows me to ascertain the firm's previous experience with component technologies, markets, platforms, and general product development. Furthermore, there are two primary platforms in this industry, Microsoft's Xbox and Sony's PlayStation, which provides a measure of platform relational resources. In addition, some game development firms in the

industry are affiliated with a platform owner, either as a subsidiary to Sony or Microsoft, or by being designated as a "first party developer."

A recent study found that firm characteristics account for 21.3% of the variance in firm performance in the video game industry (Mollick, 2012). While my dependent variable is not firm performance, this dissertation contends that product development capabilities influence firm performance. Since Mollick (2012) has been able to establish a relationship between firm characteristics and firm performance for this industry, I contend that this is an ideal industry to examine to better understand the more specific relationships between firm characteristics, product development capabilities, and firm performance.

My sample of products includes retail releases for the Xbox360 and the PlayStation 3 from 2005 to the end of 2012. Microsoft first released the Xbox 360 console in 2005, and Sony followed with the PlayStation 3 console in 2006. This timespan includes hundreds of games from dozens of videogame studios. I exclude games on Nintendo's Wii platform since the games developed for the Wii are more 'family friendly' and use motion mechanics (motion-sensing technologies). Games developed for the Xbox and PlayStation are considered targeted toward 'hardcore' game players, emphasize graphics, and do not use motion mechanics (Marino & Sarrett, 2010). 'Hardcore' gamers also tend to be more critical of a game's quality, and so there is more variance in desirability of products on these platforms. I do not include PC games in my sample because the variability in a computer's graphics and processing power can change the quality of the game's experience; whereas gaming consoles standardize the experience for all users.

4.2.1 Sample Set

I developed four rules to determine which games to include in my sample. First, I only include games that were sold in retail stores. This excludes games that were only available as downloads on Sony or Microsoft's dedicated online game networks. This allows me to only include games that attempted to be major releases which had a substantial amount of resources devoted to their production. Second, I only included the initial release of a game. If a game was previously released on past platforms, or re-released with additional content, the newer releases would not necessarily reflect the initial quality of the game or the time it took to develop the title. Third, I decided to only include games that did not require special hardware, such as musical instrument or sports accessories, microphones, or motion sensing technologies. There are two reasons for this particular decision: 1) the game playing experience is changed with the introduction of accessory items, and therefore the quality assessment of the game may be impacted, and 2) game development times may be impacted due to the complications of incorporating the functions of additional hardware accessories. Finally, I decided not to include massively multiplayer games because these games tend to have a greater amount of content than traditional console games, as well as social interaction elements that require a much higher devotion of resources to the game's development. Therefore, I decided to remove these games because they were not comparable to traditional retail releases. Many of these same sample parameters were also used in Mollick's (2012) study on the videogame industry.

I collected my initial sample of games from MetaCritic.com, which lists all of the games released for the Xbox360 and PlayStation 3. A total of 3,139 have been released for one or both of these platforms, but 249 of these games were removed because they were released after 2012. Another 1,637 games were removed from the MetaCritic.com list of releases because they were not sold in retail stores. I removed three Burger King games since they were promotional and

were not intended for mass market retail sale. Twenty seven games were removed because they were released only as additional content, such as new adventures for a previously released game. Twenty two games were removed from the sample because they had been previously released on other platforms and then re-released years later on either Xbox360 or PlayStation 3. Thirty-three games required or were sold with specific hardware, such as guitars or microphones, and so were not included in the sample. I further removed 111 games that utilized motion sensing technology. Three games were removed due to being massively multiplayer online games. Additionally, seventy games were removed because they were compilations of multiple games or were a game with additionally released content. Since additional content does not always reflect the original quality of the game, I decided to remove these compilations. Table 4.1 summarizes the construction of the final sample from the initial listing of released games for the Xbox360 and PlayStation 3.

Table 4.1: Removal of games from sample

Reason for Removal	Starting	Removed	Total	Rule
			3139	
Released After 2012	3139	249	2890	
Not in Retail Stores	2890	1637	1253	Not retail release
Promotional (BurgerKing)	1253	3	1250	Not retail release
Additional Content	1250	27	1223	Not retail release
Re-release	1223	22	1201	Not intial quality
Compilation	1201	70	1131	Not intial quality
Requires Motion Sensing	1131	111	1020	Special Hardware
Required Special Hardware	1020	26	994	Special Hardware
Includes Hardware	994	7	987	Special Hardware
Massively Multiplayer Game	987	3	984	Online Game

The resulting sample of 984 games was further sorted as illustrated by Table 4.2 below. The final sample of games included five hundred and seventy nine games released for both the Xbox360 and PlayStation 3. Two hundred and sixty nine games were released for play on the

Xbox360 only, seventeen of which were developed by either subsidiaries or first party firms of Microsoft. One hundred and thirty six games were released only for play on the PlayStation 3, of which twenty five were developed by either subsidiaries or first party firms of Sony.

Table 4.2: Final Sample per Platform

Release Platforms	N	Notes
Both Platforms	579	
Xbox 360 Only	269	17 from 1st party developers
PlayStation 3 Only	136	25 from 1st party developers
Total Games	984	

I focus my measures and analyses in this dissertation at the product level for two major reasons. First, many firms in the game development do not release products that generate revenue each year because games can be in development for multiple years. Therefore, there would be no revenues or profits for me to analyze on an annual firm level basis. Second, most game studios are privately held firms and therefore do not disclose financial data. Therefore, it becomes necessary to look at product level outcomes as proxies for a firm's product development capabilities. Measuring at the product level is a common practice in the strategic management literature on product development (Eggers, 2012; Nerkar & Roberts, 2004) and it is appropriate in this dissertation.

4.3 Dependent Variables

4.3.1 Effective Product Development Capabilities

Effective product development capabilities have already been defined as the ability for a firm to develop highly desirable products. A commonly agreed upon metric of quality in the videogame industry is a MetaCritic score. Because the effectiveness of a firm's product

development capabilities is reflected by the desirability of the firm's products, and MetaCritic aggregates expert ratings of products, I use a game's MetaCritic score as a measure of the effectiveness of a firm's product development capabilities at the time of the game's release. MetaCritic collects ratings from hundreds of independent critics and calculates a composite ratings score from 1 to 100 for each game. MetaCritic scores in the videogame industry are pervasive; so much so that game developers receive bonuses from game publishers if their game hits certain MetaCritic thresholds (Orland, 2012). MetaCritic does not calculate a score for a game unless at least four independent critics have publicly posted a review score, and MetaCritic samples 152 critics for each game. I have included a screenshot of a MetaCritic webpage in Figure 4.1 below as an example of the information provided. In this instance, the game "Last of Us," and Action Adventure game released on PlayStation 3 by the studio 'Naughty Dog,' received a score of 96 out of 100 when MetaCritic sampled 61 critics.

Figure 4.1: Screenshot of 'The Last of Us' on MetaCritic.com

4.3.2 **Efficient Product Development Capabilities**

Efficient product development capabilities are the ability of a firm to design and develop new products quickly. I use the time it takes to develop a new game as a measure of the efficiency of a firm's product development capabilities, a measure that has been used in prior product development studies (Macher & Boerner, 2006; Macher & Boerner, 2012). This measure is defined in this dissertation as the time between the release of a creative director or executive producer's last game product and the release of the focal game. As more extensively detailed in section 4.3.2.4 below, this proxy measure is correlated with primary survey data at the .33 level. Following Cohen (1988), I consider a 0.33 correlation to indicate a moderate relationship

between the variables. In an attempt to increase the accuracy of this measure, I substituted primary data (see section 4.3.2.2) for proxy data whenever possible.

4.3.2.1 Primary versus Secondary Data

Calculating the duration of production for a product efficiency measure requires both a highly accurate measure and a large number of observations. Primary data (surveying game developers) would likely be more accurate than using product release dates to estimate development time. Therefore, I conducted a survey to obtain primary data from the top managers associated with each game, and developed a proxy measure of product efficiency that would give me a large number of observations. The ultimate goal is to have a proxy measure for a large number of games that is highly correlated to the primary survey response data.

While the release date of video games is publicly known, determining how much time it took to produce any particular game is difficult. This is because many firms closely guard information on which games they are working on and when development began on those games in order to prevent imitation by rivals. Without access to primary data on game development schedules, another way to calculate duration of production is to track the people primarily involved in a game's production. The two most important people in the hierarchy of a game's development team are the creative director, who focuses on the game's design, and the executive producer, who controls the budget, timeline, and other important managerial functions of the product.

I manually reviewed the credits for each game in my sample at MobyGames.com in order to obtain the names of the creative director and executive producer for each one. This source was also used by Mollick (2012) to gather data for his study. The individual titles varied for the

senior people involved with the production of each game, for example a ‘creative director’ in one game could be called the ‘lead game designer’ in another, or the ‘executive producer’ could be the ‘lead producer’. The goal, however, was to identify the people with the most senior roles in terms of game design or product management. Regardless of their listed title in the game credits, I will refer to these people as the creative director or executive producer. I was able to identify a creative director for 568 games in the sample and an executive producer for 593 games in the sample.

4.3.2.2 Primary Survey Data

To be able to contact the managers involved in each game’s development, I looked for three pieces of contact information for all of the creative directors and executive producers: an email address, a Twitter account, and a LinkedIn address. I was able to find an email address for 84 creative directors or executive producers, of which approximately 60 email addresses were valid. I emailed these individuals a survey which asked for the date on which production began on the Xbox360 and/or PlayStation 3 games they worked on. Following game development terminology on Wikipedia (Wikipedia – Game Development), I defined the start of a game’s production as when “work has begun on a prototype, or assets or source code are being developed for the game.” Respondents were allowed to either email me directly or respond through an anonymous survey hosted by Qualtrics. In addition to the email addresses of individual creative directors and producers I obtained, I also collected 124 email addresses for game studios in my sample from their websites. I also asked for this information from firms directly on the 60 game studio websites that had contact forms. I received approximately ten email responses from studios. Based on a suggestion from an industry expert, I used a Twitter

account to contact individual game developers via their Twitter accounts. I contacted approximately 190 people via Twitter asking them to take my online Qualtrics survey.

During my survey collection I received an email response from an industry veteran, that I will keep anonymous, that my definition of production was not accurate enough for the game development industry. The person stated that there are three phases of game development, concept development, pre-production (in which a prototype is being made), and, upon the approval of a prototype by the publisher (who is financing production), full production may begin and the developer will ramp up production on the game and hire a much larger team. Further, the source stated, "Bear in mind that a publisher has no problem in keeping a project in concept forever and in pre-production for ages simply because paying for a team of 20 for 5 more months is equivalent to a one month salary for a team of 100." In response, I created a new Qualtrics survey which delineated three points of production: concept work, pre-production, and full production, and asked developers to let me know the months and years that these points of development occurred.

Next, I began to contact developers via LinkedIn, an online social networking site in which people can post their professional credentials. On this site, people are able to search for professionals and see their resumes. While LinkedIn controls how many messages people can send to people that they are not connected with, if two people are in a similar interest group, such as 'Game Development', they are able to message each other freely even if they did not know each other personally. I used these interest groups to my advantage and joined as many interest groups related to game development as possible. Three of the most important groups I joined were the 'Game Developers' group, with approximately 77,000 members; the Videogame Professionals group, with approximately 34,000 members; and the AAA – The Games Industry

group, with approximately 31,000 members. These groups enabled me to reach almost all of the game developers in my sample, but I also joined 32 other gaming related groups in order to contact specific individuals. Once this was complete, I attempted to individually contact approximately 820 game developers on LinkedIn asking them to take the updated version of my survey.

Many people and firms who responded to my inquiry refused to provide any information regarding production dates because they had signed confidentiality contracts with their employers. Studio representatives who responded were concerned that they might upset publishers by providing the requested information, even though I reiterated that the survey was completely anonymous. In the end, my first survey collected information for 32 games regarding when work on a prototype or the full game began. My second survey was able to obtain information on when production began for 70 additional games.

4.3.2.3 Proxy Measure of Efficient Product Development Capabilities

In order to increase the number of observations for my analysis, I created four proxy measures for product development efficiency that I hoped would correlate highly with the actual development times obtained from the primary survey data. First, I used the time between the release of the focal game and the release of the previous game the developer worked on regardless of whether their employer was the main studio developing the game, a co-developer, a sister studio, or an outsourced firm. Second, I created a measure which calculated the amount of time between the release of focal game and the last game the developer worked, on as part of the main studio developing the prior game; not as part of a sister studio, co-developer, or publisher. Third, I calculated the time between the release of the focal game and the last time the developer

had a leading role as a creative director or executive producer on a game. This measure attempted to measure the time between the focal game and their last management role. Fourth, I calculated the time between the release of the focal game and the last game the developer worked on in a managerial role, same as the third measure, but supplemented that data from measure two (last game worked on while employed at the main studio producing the game) if the developer never had a managerial role. For all measures, if I had data on both the creative director as well as the executive producer, I averaged the duration between the release of the focal game and the release of the prior game.

It is important to understand the process in which I obtained this proxy data. MobyGames.com traces a creative director or executive producer's prior development credits. I used a program called Helium-Scraper which can quickly take information from websites to go through each developer's profile on MobyGames.com. The program collected information on each developer's previous games, such as the date of release, the genre(s) of those games, and the platform(s) for which the games were developed. This data produced a list of 13,303 previous games in which sample set game developers were somehow credited in another game's development. I then determined for each game if the developer worked for the main studio developing the title, for a sister studio to the main developing studio, for an outsourced firm, or for the publisher. I also noted if the developer worked in a creative role on the game, such as a designer, or in a management production role. Further, I noted if the person had a lead creative or production role on any past games.

4.3.2.4 Validation of Proxy Measure

In order to validate my proxy measure I examined the correlations between my survey results and my proxy measures. Table 4.3 below displays the correlations between my survey data and proxy data. The first row titled 'Survey 2' includes only data from the second survey which asked about the time of full production, and not production of a prototype. The second row, 'Survey 2 and 1 if missing data' supplements the second survey data with data from the first survey in the case of missing information. Therefore, the second row primarily includes the time it took to release the game from when full production started, but supplements that data with information from survey 1 about the start of prototype or full production if survey 2 is missing data on the game. The table then includes information on the proxies I created. Row 3, "Proxy - Main Games," takes the time between when the focal game was released and the last previous game was released in which the top developers worked for the game's studio. Row 4, "Proxy - All Games," uses the release date of last game the top developers worked on as the start date for the focal game, regardless of type of studio the developer worked in. Therefore, they may have been in an outsourced firm for this measure. The next row, "Proxy - Prior major release," calculated the time between the release of the focal game and the last time the developer had a leading role as a creative director or executive producer. This dropped the N of the sample due to the smaller number of developers having major roles in prior games. Finally, the last row "Major release - main if missing" used the last game the developer worked on in a management capacity, similar to the last role, but supplemented the data with the time between the release of the focal game and the last game the developer worked on in the main studio if there was missing data.

Table 4.3: Relationships between Efficiency Surveys and Proxy Measures

	Mean	Std. Deviation	N	1	2	3	4	5	6
1. Survey 2	2.07	1.19	59						
2. Survey 2 and 1 if missing data	2.09	1.13	86	1.00					
3. Proxy - Main Games	2.19	1.52	306	0.33	0.29				
4. Proxy - All Games	1.90	1.31	319	0.29	0.29	0.89			
5. Proxy - Prior major release	3.34	2.24	83	-0.16	-0.16	0.55	0.51		
6. Proxy - Major release - main if missing	2.95	1.98	306	0.17	0.18	0.69	0.60	1.00	

The correlations between the primary survey data and the proxy data are low. The highest correlation is with the Survey 2 data and the release of the last game the developer worked on, assuming they were at the main studio developing the prior game. This correlation is .33. Following Cohen (1988) I consider a 0.33 correlation to indicate a moderate relationship between these variables. Therefore, the time between the release of the focal game and the release of the last game the developer worked on in the main studio creating the game is an acceptable proxy for efficiency. To increase the accuracy of the measure, I substituted data from Survey 2, since that is the most accurate data available, for data from the proxy whenever possible. This proxy/primary mix of data resulted in a final efficiency measure for each game title, which is measured in years of production.

4.4 Independent Variables

There are six independent variables examined in this dissertation: four types of firm level experience and two types of relational resources.

4.4.1: Prior Firm Experience

Using Helium-Scraper, I obtained information regarding the prior game development experience of each studio in my sample. For each game in the sample, I collected information about any

prior game the studio had developed. I recorded the prior game's title, its release date, the platform(s) the game was released on, the genre of the game, and if the game was additional content to an existing game or if the game was a collection of multiple games. If a previous game was additional content for a game, or a collection of games, I removed it from the data because I did not consider it to be a full iteration of product development experience.

4.4.1.1 Market Niche Experience

Market niche experience reflects the depth of experience a firm has in developing products for a specific customer segment. I operationalize customer segments by using a game's genre because different genres of games emphasize different game attributes such as graphics, gameplay, or story. For example, the studio BioWare makes role-playing games and claims it "creates games focused on rich stories, unforgettable characters, and vast worlds" (BioWare, 2013). By having prior experience in a genre, a firm may become make more desirable products in genres in which that could leverage their skills. MobyGames.com categorizes videogames into the following eight genres: Action, Adventure, Educational, Racing / Driving, Role-Playing, Simulation, Sports, and Strategy. To measure market niche experience, I counted the number of times the firm had previously created games in the genre of the focal game. If the focal game contained multiple genres, I averaged the firm's experience in each of these genres in their previous games. This measure is similar to prior product level studies that examined a firm's prior experience in product categories (Eggers, 2012; Macher & Boerner, 2012).

4.4.1.2. Component Experience

Component Experience is the depth of experience a firm has in working with critical components that contribute to an overall product. In the video game development industry, the most important component in a game is the "game engine" used to develop the game. A game engine is software which structures how the game's mechanics and graphics work together, independently of the game's actual creative content, such as a storyline or characters. Game engines can be created by a developer solely for use in their own game products or licensed from a firm that has developed an engine. Therefore, to measure component experience I counted how many times the firm has used the focal product's game engine in previous products.

Determining which game engine the focal game used, as well whether it was used in the developer's previous games, was difficult. I used several sources to gain information on each game's engine. First, MobyGames has records of dozens of different 2-dimensional and 3-dimensional game engines, with links to the games that those engines are used in. I web-scraped MobyGames to get a list of games that used each engine and then matched those games with the list of focal and prior games each studio in my sample had developed. For the remaining games without engine information in MobyGames, I sought information in Wikipedia. For many videogames, Wikipedia has standardized information regarding the game, often including the name of the game engine. Finally, I searched individually for game engines used in games five years prior to the focal game that I did not have information for. I choose five years prior to the focal game because game engines become obsolete compared with newer engines, so it is unlikely that firms will continue to use the same engine for more than five years if the firm wishes its products to be competitive. In the end, I had collected the engines for 1,192 of 4,910 videogames. Due to this missing information, this measure may be imperfect. Using this information, I examined the data and determined how many previous times a firm had used the

game engine in a focal game. I calculated two different variables for each game in my sample: the number of times the producing firm used that game's specific engine in the past (i.e., Unreal Engine version 3), as well as how many times the firm had used that 'family' of game engines in the past (i.e., the Unreal family of game engines). Since my theory is concerned with specific component technologies, in my analysis I use specific game engine data rather than engine family experience data.

4.4.1.3 Platform Experience

Platform experience is the depth of experience a firm has developing products for a specific platform. This dissertation analyzes data for games developed for two major platforms: Microsoft's Xbox 360 and Sony's PlayStation 3. I examined a firm's prior game releases to determine the firm's current platform experience. If the focal game was released *only* on the PlayStation 3 or Xbox360, I counted the number of times the firm had previously released a game on that platform. If the game was released on both platforms, I averaged the number of times the firm had released a game on each platform.

4.4.1.4 General Product Development Experience

In Chapter Three, I defined general product development experience as the depth of experience a firm has in developing any type of product in their industry. Correspondingly, I measure this construct with a count of the number of game titles a firm has ever released in the past. If a game was released on both the Xbox and PlayStation consoles, it was counted only once since I consider that to be a single product development iteration. This measure counts games developed by the game studio prior to the release of the focal game on any platform.

An additional means to measure this construct involves calculating years of experience a firm has from completed and concurrent products. Few game studios are large enough to have multiple titles in development simultaneously. However, for the game studios that are large enough, concurrent experience may play an important role. While concurrent development experience information may be useful, the downside is the arduous data collection this measure entails. For instance, not only would I need to estimate the time it took a firm to produce games for the Xbox 360 and PlayStation 3, but I would also need to estimate time it took the firm to make games before the sample period, possibly dating back to the 1990's in the cases of firms that developed games for the original Nintendo and Sony consoles. The time required to collect and analyze this data, if it were even available, would be unlikely to generate significant returns in terms of a better understanding of this particular construct. .

4.4.2 Relational Resources Variables

4.4.2.1 Platform Relational Resources

I consider a firm to have platform relational resources if the focal firm has a structured agreement to develop products exclusively for a platform owner. Therefore, I measure this construct with a dummy/indicator variable if the focal firm is either a subsidiary or a first party developer for Microsoft or Sony. This information was gathered from public data sources such as Wikipedia and press accounts.

4.4.2.2 Co-Developer Relational Resources

Co-developer relational resources refer to the depth and breadth of a focal firm's relationship with other firms that make components for the focal firm's products. To measure the

breadth of co-developers, I summed the number of additional firms from the credits of each game that contributed to the development of the game. In my sample, I denote three types of firms that would fall under the category of breadth of relational resources. First there are co-developers, which are listed as additional developing studio(s) by MobyGames. These firms worked together with the focal/main studio developing the title. Second, there are 'sister' firms which work with the focal development firm and share a parent company with the focal development studio. Ubisoft's Paris studio, for example, is a sister to Ubisoft's Montreal studio. Finally, there are outsourced firms which are not partners in the development of the game, but provide important services to the game's development, such as design work, artwork, modeling, or programming. The sum of the number of co-developers, sister studios, and outsourced studios is the measure of breath of relational resources. I do not count firms that provide marketing and distribution services, such as publishers, in calculating the breadth of firms to the project since their work is done mostly after the game is completed. In addition, I do not count firms that provide quality assurance, or motion capturing, since they are not involved in the long term development of the game. Lastly, I decided not to include studios hired to create sound or record voice actors for two reasons. First, sound does not play an important role in most games as compared to graphics and gameplay. Second, many of these outsourced sound effects firms credited dozens or hundreds of voice actors, so I do not include voice actors in my measure of team size (see section 4.5.1). Therefore I decided not to include any sound firms as a relational resource because it is difficult to judge their contribution to a game's development.

The measurement of the depth of experience across relational resources is complex. First, I listed the name of the focal game with all of the names of the co-developers, sister studios, and outsourced firms that worked on the game. Next, I looked at the credits of the main studio's

previous games to see if the names of these outside firms were in any of the previous credits and noted if the names were in previous credits. I kept separate counts for co-developers, sister studios, and outsourced studios.

I then calculated the depth of experience of relational resources in the following manner: If the focal game had no relational resources in any relationship type (co-developer, sister, outsourced), there was no data for the depth of the relationship since no relationship existed. I considered this to be missing data. If a focal game had a relationship of any type, for example two outsourced firms, I summed how many times those two outsourced firms were in the credits for the last three games the firm released. I chose to look at the last three games to better manage the amount of data I was looking at, as well as to make a comparison between newer and older firms. To continue our example, suppose one of the two outsourced firms worked on two of the previous three games, but the other outsourced firm had no prior experience with the focal studio. I then used that sum of two as the numerator of my depth of experience ratio for outsourced firms. The denominator of the ratio was the product of the total number of outsourced firms in the focal game, in this case two, multiplied by the number of previous games, in this case 3. Not all studios had three prior games; some only had one or two prior games, which influenced the denominator of the ratio. Therefore, in our example the outsourced relational depth would be 2 / (2*3) = 2/6 = 1/3. Finally, once I had depth of experience for the co-developers, sister studios, and outsourced studios, I averaged the experience of the three relationship types ignoring missing data for any of the types. I decided to create a single aggregate measure for the three types because my theory is at an aggregate depth of relationship level with relational resources and it does not attempt to predict different outcomes for different types of relational actors.

4.5 Control Variables

4.5.1 Team Size

Following Mollick's (2012) work in the videogame industry, it is important to control for the amount of resources a game studio devotes to the development of a game. Like Mollick (2012), I used a count of the number of employees at the focal firm involved in the production of the videogame. This information came from the game's credits. I did not count individuals that are ancillary to the game's production, such as voice actors, testers, movie production crews and researchers. Instead, I focused on the number of designers, producers, programmers, artists, and managers listed in each game's credits to derive a team size for that game's production.

4.5.2 Efficiency and Effectiveness

Highly desirable products may take longer to create and games with shorter development cycles may not be as desirable. Therefore, it is important to include effectiveness of the product in the model that has efficiency as the dependent variable and efficiency in the model that has effectiveness as the dependent variable. A potential concern using this variable is that I predict that it will co-vary with all of the other independent variables. Therefore, multicollinearity may become an issue, which I address in section 5.2.

4.5.3 Number of Platforms

Creating products for multiple platforms requires more time and resources. Therefore, I do control for whether a game product is developed for only one platform (PlayStation3 or Xbox360) or for both.

4.5.4 Age of Firm

The age of the firm may play an important role in representing their long term experience. I have included this measure as a control variable. The founding year of the firm was gathered from public sources such as the firm's website if the studio is still in operation or from Wikipedia for defunct studios. I then subtracted this year from the year the focal game was released in order to arrive at the age of the firm at the time of the game's release.

4.5.5 Developer Experience

Mollick (2012) determined that individuals play an important role in the development of videogames. I control for the prior experience of the top individuals involved in the production of a game by calculating the years of experience of both the creative director and executive producer of the focal game. For each person, I count the years between the release of their first game to the year of the focal game's release, and then average the years of experience the two individuals to proxy their experience. If I only had data for one person, I only used that length of experience.

4.5.6 Product Complexity

In an attempt to control for the complexity of a game, which may influence the desirability of the game as well the time needed to develop the game, I collected a measure of game complexity. For games in my sample that were also released on PC, I gathered information on the minimum hard drive size required by the PC version of the game. The amount of hard drive space required by a game on the PC indicated that more programming, artwork and other data needed to be created to make the game run, and thus served as an indicator of the

complexity of the game. I collected this information from game-debate.com as well as several online retailers such as Steam and Gamefly.

4.6 Statistical Analysis

I used stepwise OLS regression for my analysis. I regressed the *efficiency* and *effectiveness* of the firm's product development capabilities onto the constructs of interest from Chapter Three as well as the control variables detailed in this chapter. The results of this analysis will be detailed in Chapter Five.

4.6.1 Additional Analyses

4.6.1.1 Analysis #1

To bolster the validity of my findings, and to understand their substantive significance, I conduct additional analyses that I did not originally propose in Chapter Three. Specifically, I wish to understand how the effectiveness of product development capabilities influences the financial performance of the firm. Therefore, I regressed the number of individual game title units sold on the effectiveness of the firm's product development capabilities as well as two control variables. The number of units sold of each title is obtained via sales data provided by VGChartz.com. In this regression I also control for the number of critics that MetaCritic used to calculate this score. This measure reflects the amount of public knowledge of the game. Additionally, I control for whether or not the game is released on both the Xbox360 and the PlayStation3, or only one of the two platforms. This is important because if the game was released on both platforms there is a higher installed base of potential customers for the game, which can influence the sales for that game.

4.6.1.2 Analysis #2

When a game is developed for both the Xbox360 and the PlayStation 3, it receives a MetaCritic score for both releases. This provides an opportunity to examine how differences in platform experience influence the effectiveness of the firm's product development capabilities. This is because all other factors, such as developer experience, relational resources, team size, and time to produce the game remain the same. Therefore, I examine the change in MetaCritic score between the two releases on the difference in platform experience. This aids our understanding of the importance of platform experience.

4.7 Conclusion

This chapter outlines my methodology for this dissertation. I have summarized my constructs and measures in Table 4.4 below. The results of my data analysis will be described in the next chapter. Chapter six will include a discussion of my results and their implications for the new product development literature, the experience literature, and the literature on relational resources.

Table 4.4: Summary of Constructs and Measures

Construct	Measure
Dependent Variables	
Effectiveness of Product Development Capabilities	MetaCritic Score of the game
Efficiency of Product Development Capabilities	The time between the release of the focal game and the last game the creative director and executive producer worked on as a member of the main studio developing the game. This data is supplemented with primary survey data.
Independent Variables	
Market Niche Experience	The number of previous games the firm developed in the genre of the focal game
Component Experience	The number of times the firm has used the graphics engine in the focal game in previous games
Platform Experience	The number of times the firm has released games for the platform the focal game is being released on
General Product Development Experience	The number of times the firm has released game products
Platform Relational Resources	Indicator variable whether or not the firm is a subsidiary or in an alliance with the platform owner
Breadth of Relational Resources	The number of co-developers of the focal product, excluding post-development firms such as publishers
Depth of Relational Resources	Weighted average of the number of times the firm has worked with the co-developers of the focal game in the past three games
Control Variables	
Team size	The number of designers, producers, programmers, artists and managers working on the game
Effectiveness or Efficiency	See dependent variables above
Number of platforms	The number of platforms the game was released on
Age of Firm	The number of years between the release of the focal g ame and the establishement of the firm
Developer Experience	The average number of years of experience the creative director and executive producer have in the industry
Product Complexity	The harddrive size the game requires for installation on a PC

5.0 ANALYSES AND RESULTS

5.1 Introduction

This chapter describes the analysis of the data set described in Chapter Four and presents the results of that analysis. First, I calculate the descriptive statistics of my measures and discuss the impact of these findings on the final sample. Next, I conduct an OLS regression analysis on my data sample and present the results. Following the OLS analysis, I conduct supplementary analyses of my data to address questions raised by the initial results. Detailed discussion of the overall findings of this analysis will be included in Chapter Six.

5.2 Description of Data

This section details the descriptive statistics for the data used in my analyses. Information on the sample data, including rationale for selection and inclusion, was presented in Chapter Four. Table 5.1 below displays the descriptive statistics for all of the variables in the final sample. Several of the measures have sharply lower N values than the initial sample total of 984. For example, there is a low N for depth of relational resources since many games in the sample were the first product released by a studio. Further, it was not possible to identify the engine used for all of the games in the sample, which prevented me from being able to calculate component experience for some games. Market experience and total experience have high maximums and standard deviations due to the high variance in the ages of game producing firms. Although some games in the sample are the first product from their studios, other firms, such as Capcom and Electronic Arts, have been in the industry for decades, which has given them time to release a large number of games.

Table 5.1: Descriptive Statistics for Sample

Measure	N	Mean	Std. Dev.	Min	Max
1. Effectiveness of Product Development Capabilities	914	68.65	14.71	21.00	98.00
2. Efficiency of Product Development Capabilities	329	2.16	1.48	0.00	11.97
3. Market Experience	626	12.20	23.49	0.00	166.00
4. Component Experience	342	1.86	3.05	0.00	17.00
5. Platform Experience	626	2.78	4.77	0.00	33.00
6. General Product Development Experience	626	18.03	30.83	0.00	207.00
7. Platform Alliance	984	0.04	0.20	0.00	1.00
8. Breadth of Relational Resources	484	1.92	2.75	0.00	18.00
9. Depth of Relational Resources	221	0.13	0.20	0.00	1.00
10. Team Size	483	106.84	66.24	5.00	445.00
11. Firm Age	576	13.81	7.16	0.00	42.00
12. Number of Platforms	626	2.93	1.49	1.00	10.00
13. Developer Experience	439	10.82	4.87	0.00	24.54
14. Product Complexity	281	8486.23	4468.25	300.00	35000.00

Because the N for each measure varies, I examine the data in both pair-wise and list-wise deletion methods. Table 5.2 displays the means, standard deviations, and correlations for the variables in the sample data. The bottom left section of table displays the pair-wise correlations, whereas the top right section of the table displays the list-wise correlations.

I examined each variable to see if the means and standard deviations differed significantly between the list-wise and pair-wise deletion methods. The majority of the means are similar and when there is a difference in the means, the difference is less than one standard deviation. This suggests that there is not a substantial difference between the pair-wise and list-wise samples.

Table 5.2: Descriptive Statistics and Correlations for Sample

	Pairwise		Listwise (N=114)															
	Mean	Std. Dev.	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Effectiveness	68.65	14.71	75.17	14.22		.12	.00	-.37**	.10	.01	.29**	.18	.11	.26**	.24*	-.11	-.07	NA
2. Efficiency	2.16	1.48	2.07	1.43	.02 (329)		-.01	-.22*	-.00	.00	0.02	-.03	-.01	.06	.00	-.10	-.02	NA
3. Market Experience	12.20	23.49	15.90	28.60	.14** (622)	-.09 (323)		.25**	.88**	.96**	0.10	.12	-.07	.26**	.54**	.09	.03	NA
4. Component Experience	1.86	3.05	2.31	3.46	-.14** (340)	-.19** (204)	.20** (342)		.22*	.22*	-.17	-.11	-.11	-.14	.10	.05	.11	NA
5. Platform Experience	2.78	4.77	4.08	6.16	.19** (622)	-.10 (323)	.85** (626)	.23** (42)		.88**	-.06	.19*	-.05	.48**	.65**	-.01	.06	NA
6. General Product Development Experience	18.03	30.83	23.43	39.08	.11** (622)	-.08 (323)	.94** (626)	.18** (342)	.83** (626)		-.10	.15	-.06	.28**	.59**	.06	.04	NA
7. Platform Alliance	0.04	0.20	0.08	0.27	.22** (914)	.05 (329)	-.07 (626)	-.11* (342)	-.04 (626)	-.09* (626)		.02	.07	-.02	.03	-.46**	.21*	NA
8. Breadth of Relational Resources	1.92	2.75	3.73	3.14	.10* (484)	-.03 (320)	.07 (484)	-.04 (291)	.10* (484)	.08 (484)	.01 (484)		-.15	.34**	.03	-.07	.00	NA
9. Depth of Relational Resources	0.13	0.20	0.16	0.22	.09 (221)	-.05 (159)	-.01 (221)	-.10 (153)	-.02 (221)	-.02 (221)	.05 (221)	-.09 (221)		.05	.22*	.00	-.07	NA
10. Team Size	106.84	66.24	132.24	71.20	.37** (484)	.02 (320)	.24** (483)	.07 (291)	.42** (483)	.23** (483)	.06 (483)	.19** (483)	.02 (221)		.46**	.04	-.06	NA
11. Firm Age	13.81	7.16	15.38	6.51	.15** (572)	-.08 (310)	.51** (576)	.15** (327)	.53** (576)	.58** (576)	-.08 (576)	.06 (456)	.15* (213)	.28** (455)		.03	-.01	NA
12. Number of Platforms	2.93	1.49	2.92	1.24	.00 (622)	-.12* (323)	.07 (626)	.13* (342)	.03 (626)	.06 (626)	-.24** (626)	-.10* (484)	-.12 (221)	.07 (483)	.11** (576)		-.16	NA
13. Developer Experience	10.82	4.87	11.87	4.13	.04 (439)	-.03 (317)	.11* (439)	.07 (271)	.13** (439)	.10* (439)	.14** (439)	.09 (439)	-.04 (205)	.12* (483)	.11* (413)	.05 (439)		NA
14. Product Complexity	8,486.23	4,468.25	NA	NA	.30** (281)	.26** (143)	.01 (230)	-.16* (167)	.06 (230)	.02 (230)	.05 (281)	.39** (203)	.12 (105)	.35** (203)	.06 (216)	-.02 (230)	.17* (188)	

Pair-wise correlations in bottom left, list-wise correlations in top right
Pair-wise N in parentheses, list-wise N = 114
**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Upon examination of all of the descriptive statistics for the variables, I removed "product complexity" from the list-wise correlations for two reasons. First, inclusion of the variable dropped the N from 114 to 63 in the correlation matrix. Second, the drop in N eliminated the variance in the platform relationship variable. This is a result of the method used to calculate product complexity. If the studio developing a game has an exclusive relationship with a platform owner such as Microsoft or Sony, there is no PC version created, and so no data exists for the amount of hard-drive space needed to install the game on a PC. Platform owner do not release PC versions of their exclusive titles in order to encourage consumers to purchase their platform. Therefore, to avoid a low N and to maintain variance in the platform relationship variable, which is one of my key independent variables, I removed game complexity from the list-wise correlations. Game complexity was also not included in my subsequent regressions because its inclusion reduced the N of the model greatly because OLS analysis requires list-wise deletion of observations with missing data.

Several of my independent and control variables are highly correlated with each other. For example, market experience is highly correlated with platform experience and total experience. In an attempt to address the multicollinearity, I calculated the value that would be three standard deviations above the mean for each of four firm level experience variables for the full sample and made that value the maximum. This transformation did not remedy the multicollinearity between the variables so I decided to leave them untransformed. Further, I did not attempt to center the variables to remove the multicollinearity because mean centering is a linear transformation and would have no effect on the correlation between the variables. I do, however mean center variables before I multiply them together to test interaction effects.

With regard to general product development experience, the multicollinearity may occur because studios will specialize in one market niche. Therefore the high number of games they produce in a market genre increases the total number of games they have produced. The regression models do not include both market experience and total experience in the same model so multicollinearity is not a problem. However, market experience and platform experience are highly correlated and occur in the same models when I regress the effectiveness of a firm's product development capabilities. It appears that if a studio releases games for a platform, gaining experience with that platform, the studio also tends to continue to release games in the same genre. This multicollinearity is a cause for concern because it influences my subsequent OLS regressions. Finally, total experience is highly correlated with platform experience, and these variables are both included in models in which I regress product efficiency. It appears that studios that have produced a large number of games in the past have the capability to release games in rapid succession for a platform, and therefore there is high multicollinearity. Again, this collinearity will need to be addressed when examining my regression analyses. Other relationships also display some degree of multicollinearity. Firm age is highly correlated with the market experience of the studio, the platform experience of the studio, and the general product development experience of the studio. This is not surprising since older studios will have developed more products in the genres they specialize in, produced more games for platforms, and developed a larger overall number of games.

5.3 Test of Hypotheses

The following sections present the analysis of the data using OLS regression. I elected to use OLS regression due to its robustness and ability to make substantive comparisons of effect

size with the R^2 metric. Further, OLS is robust when dealing with data that has skewness and kurtosis, which my data set contains. I organized the models in my tables to more fully understand the unique effects of my independent variables and control variables before I combine both types of variables. I first examine the results with regard to the effectiveness of product development capabilities, followed by the efficiency of product development capabilities. In all tables, standardized beta coefficients are reported in parentheses. All interaction terms were list-wise mean-centered before multiplying the measures.

5.3.1 Effectiveness of Product Development Capabilities

Table 5.3 regresses the effectiveness of a firm's product development capabilities, measured by MetaCritic score, against independent and control variables. Panel A allows for the sample size to be as large as possible given the variables included in each model, panel B restricts the sample size to the 114 observations that include data for each variable. Column r_{xy} displays the bivariate correlations for the samples. Table 5.3 includes models with squared terms which I utilize in ad-hoc analyses that examine the possibility of curvilinear relationships.

Column r_{xy} shows that market niche experience does influence the effectiveness of a firm's product development capabilities in panel A, but it does not in panel B. However, this linear relationship is not robust in subsequent models and therefore does not support Hypothesis 1 which suggested that increased experience in a market niche would aid the firm in creating more effective products.

Increased firm level experience with components is shown to hurt the effectiveness of a firm's product development capabilities in column r_{xy} in both panels. For each prior experience with a specific game engine, the firm loses 1.06 MetaCritic points in the game's quality in Model

14. Models 4, 7, 9, and 11 also have a negative linear relationship between effectiveness and component experience which makes the findings more robust. This relationship occurs in both panels A and B. While this is not a substantive drop in quality, it is interesting that the findings are the reverse of what I hypothesized. Therefore, Hypothesis 2a is not supported. More detailed thoughts regarding why this relationship is inverse to the hypothesis are discussed in Chapter Six.

Increased experience with a platform shows a positive bivariate correlation with effectiveness in panel A and B. This linear relation is supported in Model 4 and this relationship is also significant in Model 11 which includes all linear independent variables. However, the relationship is no longer supported in Model 14 which includes the control variables, of which firm age is significant. Therefore, there is some evidence to support Hypothesis 3a which proposed that increased experience with a platform would aid a firm in creating superior products, however this relationship does not hold with the introduction of control variables. It is important to note that the substantive effect of platform experience is minor. Per Model 12, the average effect size between panels A and B is an increase of 1.54 in MetaCritic score for each prior development of a game on a platform. This is a small increase in effectiveness, which may not be considered to have a substantive effect.

Column r_{xy} of panel A suggests that there is a weak relationship between the breadth of co-developers a firm engaged to work on its product and the effectiveness of the product ($p < .1$); but this relationship is not significant in panel B. Interestingly, Model 6 of panel B shows that breadth of co-developers is a statistically significant predictor of effectiveness. However, because this relationship was not significant as a bivariate correlation, the variables statistical significance in Model 6 is due to multicollinearity with depth of experience with relational

resources. Therefore, the findings do not support Hypothesis 6a, which proposed a positive relationship. These findings are surprising given the literature that supports the positive effects of relational resources on effectiveness of product development capabilities (Srivastava & Gnyawali, 2011; Gnyawali et. al., 2010).

Hypothesis 7a proposed an interaction effect between the firm's market niche experience and the depth of experience the firm had with its co-developers on the effectiveness of the firm's product development capabilities. The interaction term does not have a significant bivariate correlation with effectiveness, nor is the variable statistically significant in any model. These results do not support Hypothesis 7a.

There is some support for an interaction effect between the firm's depth of relational resources and its component experience on the effectiveness of the firm's product development capabilities. Column r_{xy} for both panels display a positive and significant ($p < .05$) relationship between the interaction term and effectiveness. Model 9 in panel B finds the interaction to be significant ($p<.05$), whereas in panel A the interaction is not statistically significant, though close with $p = .102$.Futher,the interaction term remains significant throughout all subsequent models in panel B. To test the interaction, I split component experience into three groups. Group 0 represents studios with no previous experience with the game engine. Group 1 represent studios with one prior experience with the game experience. Group 2 represents studios with more than 1 prior experience with the game engine. Due to skewness in the data, group 0 had 48.2 percent of the population, group 1 had 19.6%, and group 2 had 32.2%. As Figure 5.1 below shows, studios that have used a game engine only once before, and have high levels of previous experience with co-developers, do poorly in terms of having effective product development capabilities. However, when a firm has lot of experience with an engine, prior experience with co-developers

Table 5.3: Regression of Effectiveness of Product Development Capabilities

Panel A	rxy (N)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
Constant		68.52**	74.80**	67.86**	73.95**	72.80**	70.47**	75.11**	73.42**	75.97**	73.43**	74.58**	76.60**	65.57**	65.49**	68.05**
Market Experience	.14** (622)	.21 (.34)**			-.03 (-.05)	.04 (.07)		-.09 (-.19)	-.14 (-.29)		.04 (.07)	-.09 (-.18)	-.09 (-.19)		-.07 (-.13)	.03 (.06)
Market Experience²	.10* (622)	-.001 (-.22)**				.00 (-.02)			.001 (.20)				.00 (.11)			.00 (-.06)
Component Experience	-.14* (340)		-.11 (-.03)		-.82 (-.18)**	-.54 (-.12)		-1.41 (-.33)**	-.84 (-.20)	-1.08 (-.26)**		-1.17 (-.28)**	-.85 (-.20)		-1.06 (-.26)**	-1.42 (-.35)
Component Experience²	-.15**(340)		-.05 (-.13)			-.04 (-.09)			-.05 (-.15)				-.03 (-.09)			.03 (.07)
Platform Experience	.19** (622)			1.29 (.43)**	.57 (.23)**	1.04 (.42)**		.75 (.32)**	1.62 (.69)**			.74 (.31)**	1.55 (.69)**		.11 (.05)	.55 (.24)
Platform Experience²	.13** (622)			-.04 (-.27)**		-.03 (-.30)			-.04 (-.47)				-.04 (-.46)			-.03 (-.34)
Co-Developer Relational Resources (Breadth)	.10* (484)						.55 (.11)	.46 (.10)	.55 (.12)			.47 (.10)	.61 (.13)		.54 (.12)	.68 (.15)
Co-Developer Relational Resources (Depth)	.09 (211)						6.71 (.10)	4.71 (.07)	3.78 (.06)	6.39 (.10)	6.70 (.10)	7.02 (.11)	5.73 (.09)		3.60 (.06)	2.80 (.04)
Depth of Relational Resources * Component Experience	.21**(153)									3.24 (.14)		3.23 (.14)*	3.27 (.14)		5.01 (.23)**	5.50 (.25)**
Depth of Relational Resources * Market Experience	.02 (221)										.19 (.06)	-.01 (-.00)	-.09 (-.03)		.02 (.01)	-.15 (-.04)
Team Size	.37** (483)													.07 (.30)**	.01 (.06)	.01 (.05)
Firm Age	.15** (572)													.20 (.10)*	.68 (.31)**	.62 (.28)**
Number of Platforms	.00 (622)													-.67 (-.07)	-.90 (-.08)	-1.02 (-.09)
Firm Efficiency	.02 (329)													.01 (.00)	.33 (.03)	.40 (.04)
Avg Developer Experience	.04 (439)													-.25 (-.07)	-.15 (-.04)	-.19 (-.06)
N		622	340	622	340	340	221	153	153	153	221	153	153	304	114	114
R		.166	.149	.218	.231	.254	.141	.393	.414	.347	.112	.413	.432	0.356	.541	.549
R²		.028	.022	.048	.053	.068	.02	.155	.171	.120	.012	.171	.187	.127	.293	.301
Adjusted R²		.024	.016	.045	.045	.048	.011	.126	.125	.102	-.001	.131	.129	.112	.209	.194

Panel B	rxy (N)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15
Constant		75.20**	78.20**	72.99**	77.04**	75.27**	70.40**	74.28**	72.28**	75.57**	75.28**	73.37**	71.41**	70.39**	65.49**	68.05**
Market Experience	.00 (114)	-.01 (-.01)			-.14 (-.28)	-.13 (-.26)		-.12 (-.25)	-.09 (-.18)		.02 (.04)	-.11 (-.23)	.00 (.00)		-.07 (-.13)	.03 (.06)
Market Experience²	.00 (114)	.00 (-.01)				.00 (.142)			.00 (.10)				.00 (-.03)			.00 (-.06)
Component Experience	-.37** (114)		-.93 (-.23)		-1.61 (-.39)**	-.96 (-.23)		-1.51 (.37)**	-1.06 (-.26)	-1.21 (-.30)**		-1.25 (-.30)**	-1.33 (-.32)		-1.06 (-.26)**	-1.42 (-.35)
Component Experience²	-.36** (114)		-.05 (-.15)			-.06 (-.19)			-.05 (-.14)				-.00 (-.01)			.03 (.07)
Platform Experience	.10 (114)			.89 (.39)	.98 (.43)**	1.73 (.75)**		.88 (.38)**	1.64 (.71)*			.90 (.39)**	1.53 (.66)*		.11 (.05)	.55 (.24)
Platform Experience²	.06 (114)			-.03 (-.30)		-.04 (-.47)			-.05 (-.51)				-.05 (-.51)			-.03 (-.34)
Co-Developer Relational Resources (Breadth)	.18 (114)						.90 (.20)**	.50 (.11)	.59 (.13)			.48 (.11)	.66 (.15)		.54 (.12)	.68 (.15)
Co-Developer Relational Resources (Depth)	.11 (114)						9.14 (.14)	5.75 (.09)	4.53 (.07)	7.00 (.11)	8.84 (.14)	9.07 (.14)	6.88 (.11)		3.60 (.06)	2.80 (.04)
Depth of Relational Resources * Component Experience	.27** (114)									4.17 (.19)**		4.09 (.19)**	4.66 (.11)**		5.01 (.23)**	5.50 (.25)**
Depth of Relational Resources * Market Experience	.02 (114)										.27 (.08)	.18 (.05)	-.09 (-.03)		.02 (.01)	-.15 (-.04)
Team Size	.26** (114)													.04 (.19)*	.01 (.06)	.01 (.05)
Firm Age	.24* (114)													.34 (.16)	.68 (.31)**	.62 (.28)**
Number of Platforms	-.11 (114)													-1.41 (-.12)	-.90 (-.08)	-1.02 (-.09)
Firm Efficiency	.12 (114)													.94 (.09)	.33 (.03)	.40 (.04)
Avg Developer Experience	-.07 (114)													-.27 (-.08)	-.15 (-.04)	-.19 (-.06)
N		114	114	114	114	114	114	114	114	114	114	114	114	114	114	114
R		.005	.370	.141	.431	.445	.226	.449	.464	.413	.130	.484	.500	0.342	.541	.549
R²		.000	.137	.02	.186	.198	.051	.202	.216	.171	.017	.235	.250	.117	.293	.301
Adjusted R²		-.018	.122	.00	.163	.153	.034	.165	.156	.148	-.010	.184	.177	.076	.209	.194

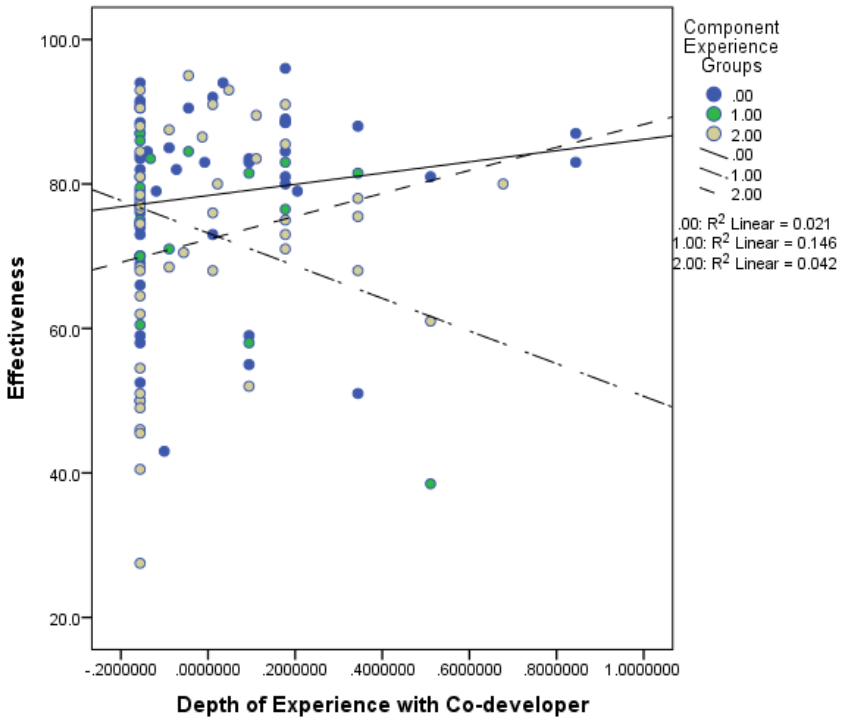
Standardized beta coefficients in parentheses

** p < .05

* p < .10

does increase the effectiveness of their product development capabilities. The results are similar for firms with no prior experience with a game engine; the effectiveness of the firm's product development capabilities increase with increased experience with their co-developers. These findings do not support Hypothesis 7b which suggested that increases in prior experience with co-developers combined with high experience with components would lead to the highest levels of efficiency product development capabilities.

Figure 5.1: Interaction of Component Experience and Depth of Relationships on Effectiveness



Model 14 includes all linear independent and control variables in the model. Component experience remains significant, but not in the direction hypothesized. The interaction between prior component experience and prior co-developer experience is also significant, but as Figure 5.1 displays the interaction was also not as expected. Firm age was the only significant control variable in this fully specified linear model.

5.3.2 Efficiency of Product Development Capabilities

Table 5.4 below presents the results when I regress efficiency on the variables of interest, with panel A including all possible observations for a model and panel B including the same 114 observations for which we have data for all observations. Column r_{xy} displays the bivariate correlations between the variable and efficiency.

Increased experience with the main components of a product, in this context the game's engine, statistically reduces the time it takes to develop a game per the linear bivariate correlation ($p < .05$). This linear relationship is also supported in models 4, 7, 10 and 13 making the finding more robust in both panels. According to Model 13, for each prior product development iteration with the game's engine, the studio will save .09 of a year, or 32.9 days, developing a game. Given that mean team size during full production of a game is approximately 107 people, this saves a studio a great deal of money, approximately equivalent to paying an individual for nine and a half years. Therefore, this is a finding of statistical and substantive importance, supporting Hypothesis 2b.

The correlation and models that include the linear platform experience variable find that prior experience with a platform does not influence product development speed. This is an interesting finding since prior studies have found learning curve effects in production (Argote, 1993; Hatch & Mowery, 1998; Schilling et al., 2003; Yelle, 1979). In the next section, I perform ad-hoc analyses to further explore these relationships, but the current findings do not support Hypothesis 3b.

Hypothesis 4 proposed a curvilinear relationship between general product development experience and efficiency. Model 2 in panel A finds the linear and squared variables to be statistically significant, providing some support for the hypothesis; however the variables in panel B are not statistically significant. Figure 5.2 displays the scatter-plot of general product

Table 5.4: Regression of Efficiency of Product Development Capabilities

Panel A	r_{xy} (N)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
Constant		2.41**	2.40**	2.38**	2.47**	2.62**	2.19**	2.42**	2.55**	2.11**	2.41**	2.68**	2.86**	1.98*	2.36*
Component Experience	.19** (204	.29 (-.57)**			-.08 (-.15)*	-.27 (-.53)**		-.10 (-.23)**	-.29 (-.70)**		-.10 (-.23)*	-.29 (-.70)**		-.09 (-.21)*	-.30 (-.73)**
Component Experience²	-.13 (204)	.02 (.41)**				.02 (.41)**			.02 (.48)			.02 (.48)			.02 (.54)*
Platform Experience	-.10 (323)		-.14 (-.48)**		-.02 (-.08)	-.11 (-.39)		.01 (-.02)	.03 (.14)	-.05 (-.15)**	.00 (-.00)	.04 (.15)		-.03 (-.12)	.01 (.06)
Platform Experience²	-.04 (323)		.01 (.38)**			.01 (.48)			-.00 (-.20)			-.00 (-.28)			.00 (.56)
Total Product Development Experience	-.08 (323)			-.02 (-.41)*	-.01 (-.34)	-.01 (-.15)		-.01 (-.22)	-.01 (-.30)		-.01 (-.22)	-.01 (-.32)		-.01 (-.19)	-.01 (-.31)
Total Product Development Experience²	-.03 (323)			.00 (.35)**	.00 (.38)*	.00 (.03)		.00 (.26)	.00 (.45)		.00 (.25)	.00 (-.50)		.00 (.26)	.00 (.56)
Co-Developer Relational Resources (Depth)	-.05 (159)						-.32 (-.05)	-.27 (-.04)	-.23 (-.37)		-.24 (-.04)	-.21 (-.03)		-.25 (-.04)	-.24 (-.04)
Platform Relational Resources	.05 (323)						.22 (.04)	-.28 (-.05)	-.39 (-.08)	-.06 (-.01)	-.41 (-.08)	-.58 (-.96)		-.87 (-.17)	-1.07 (-.20)
Platform Experience * Platform Relationship	-.01 (323)									-.22 (-.10)	-.11 (-.06)	-.14 (-.07)		-.13 (-.07)	-.16 (-.08)
Team Size	.02 (320)												.00 (.03)	.00 (-.04)	.00 (.05)
Firm Age	-.08 (310)												-.02 (-.09)	-.01 (-.05)	.01 (.06)
Number of Platforms	-.12* (323)												-.12 (-.12)*	-.16 (-.14)	-.18 (-.15)
Effectiveness	.02 (329)												.00 (.00)	.01 (.06)	.01 (.07)
Avg. Developer Exp	-.03 (317)												-.01 (-.04)	.01 (-.02)	-.00 (-.01)
N		204	323	323	204	204	159	116	116	323	116	116	304	114	114
R		.240	.177	.148	.236	.290	.003	.247	.295	.126	.251	.299	.161	.288	.340
R^2		.058	.031	.022	.055	.084	.003	.061	.087	.016	.063	.090	.026	.083	.116
Adjusted R^2		.048	.025	.016	.037	.056	-.009	.009	.019	.007	.002	.012	.009	-.026	-.009

Panel B	r_{xy} (N)	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
Constant		2.40**	2.16**	2.21**	2.34**	2.47**	2.09**	2.42**	2.54**	2.06**	2.41**	2.75**	1.70*	1.98*	2.36*
Component Experience	-.22* (114)	.25 (-.62)**			-.09 (-.22)*	-.28 (.67)**		-.10 (-.23)**	-.29 (-.71)**	-.01 (-.04)	.10 (-.23)*	-.29 (-.71)**		-.09 (-.21)*	-.30 (-.73)**
Component Experience²	-.16 (114)	.02 (.42)				.02 (.47)			-.02 (.49)*			.02 (.49)			.02 (.54)*
Platform Experience	-.00 (114)		-.05 (-.21)		.01 (.03)	.03 (.12)		.01 (.04)	.05 (.21)		.00 (.02)	.06 (.24)		-.03 (-.12)	.01 (.06)
Platform Experience²	.02 (114)		.00 (.23)			-.00 (-.17)			-.00 (-.28)			-.00 (-.37)			.00 (.56)
Total Product Development Experience	.00 (114)			-.01 (-.31)	-.01 (-.61)	-.01 (-.29)		-.01 (-.24)	-.01 (-.35)		-.01 (-.24)	-.01 (-.39)		-.01 (-.19)	-.01 (-.31)
Total Product Development Experience²	.04 (114)			.00 (.33)	.00 (.26)	.00 (.42)		.00 (.26)	.00(.51)		.00 (.25)	.00 (.57)		.00 (.26)	.00 (.56)
Co-Developer Relational Resources (Depth)	-.02 (114)						-.09 (-.01)	-.20 (-.03)	-.17 (-.03)		-.17 (-.03)	-.15 (-.02)		-.25 (-.04)	-.24 (-.04)
Platform Relational Resources	-.02 (114)						-.08 (-.02)	-.29 (-.05)	-.42 (-.08)	-.23 (-.04)	-.43 (-.08)	-.62 (-.12)		-.87 (-.17)	-1.07 (-.20)
Platform Experience * Platform Relationship	-.03 (114)									-.12 (-.07)	-.12 (-.06)	-.15 (-.08)		-.13 (-.07)	-.16 (-.08)
Team Size	.06 (114)												.00 (.06)	.00 (-.04)	.00 (.05)
Firm Age	.00 (114)												-.01 (-.05)	-.01 (-.05)	.01 (.06)
Number of Platforms	-.10 (114)												-.11 (-.09)	-.16 (-.14)	-.18 (-.15)
Effectiveness	.12 (114)												.01 (.10)	.01 (.06)	.01 (.07)
Avg. Developer Exp	-.02 (114)												-.01 (-.03)	.01 (-.02)	-.00 (-.01)
N		114	114	114	114	114	114	114	114	114	114	114	114	114	114
R		.259	.075	.106	.249	.286	.021	.247	.297	.050	.251	.303	.160	.288	.340
R^2		.067	.006	.011	.057	.082	.000	.061	.088	.003	.063	.092	.026	.083	.116
Adjusted R^2		.050	-.012	.006	.022	.030	.018	.008	.019	.025	.001	.013	-.019	-.026	-.009

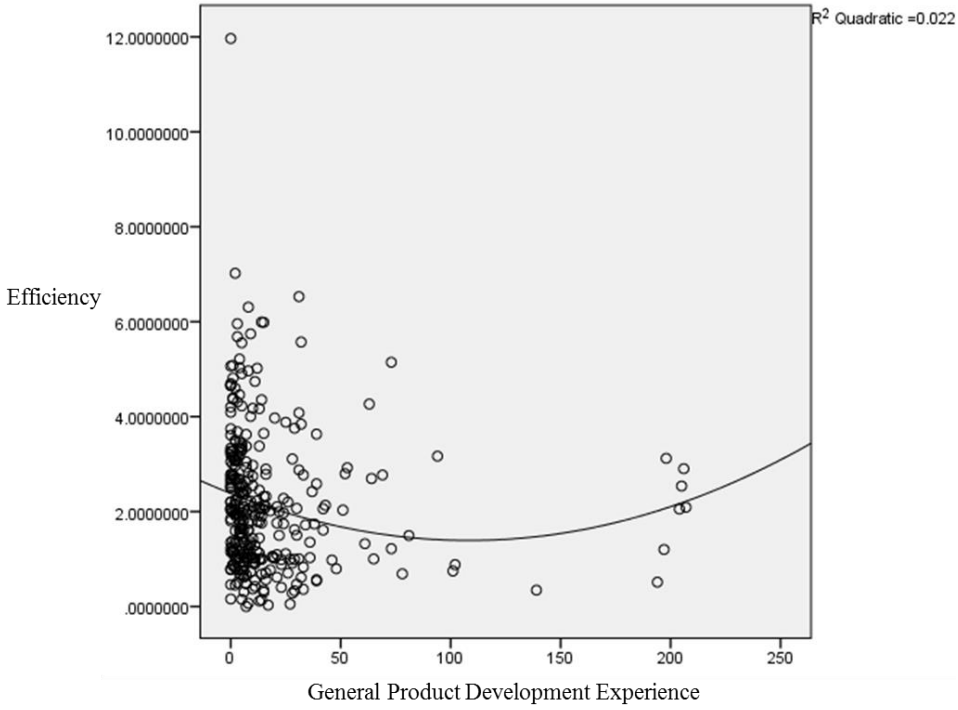
Standardized beta coefficients in parentheses

** p < .05

* p < .10

development experience and efficiency, using as many observations as possible since the variables were significant in panel A. The line displays a U-shape, suggesting that as general product development increases firm's become more efficient. However, at approximately one hundred games of experience a firm will no longer have efficiency gains and actually lose efficiency. Therefore, there is some support for Hypothesis 4 regarding increased efficiency at a diminishing rate.

Figure 5.2: Plot of General Product Development Experience and Efficiency



The depth of prior experience with co-developers had no effect on the efficiency of product development per Model 6 and the correlations which does not support Hypothesis 6b. Model 6 also and the correlations shows that the speed of production is not influenced by a firm's exclusive with a platform owner, such as when a game studio is an exclusive developer for Sony or Microsoft. This finding does not support Hypothesis 5 which suggested that there

would be a positive relationship between production efficiency and a firm's relationship with the platform owner.

Model 9 examines the proposed substitution interaction effect between prior platform experience and a firm's relationship with the platform owner. No interaction was found to be statistically significant, which does not support Hypothesis 7c. Platform experience was found to be statistically significant at the $p<.05$ in panel A. However, because the correlation was not significant, the significant variable in model 9 is due to multicollinearity.

Model 10 includes all of the independent variables, including the interaction terms. Component experience is the only variable that is robustly statistically significant. Model 13 adds the control variables to the hypothesized relationships in model 10, of which none of the control variables are significant. However, with the inclusion of the control variables component experience remains significant and therefore is a robust finding.

5.3.3 Ad-hoc analyses

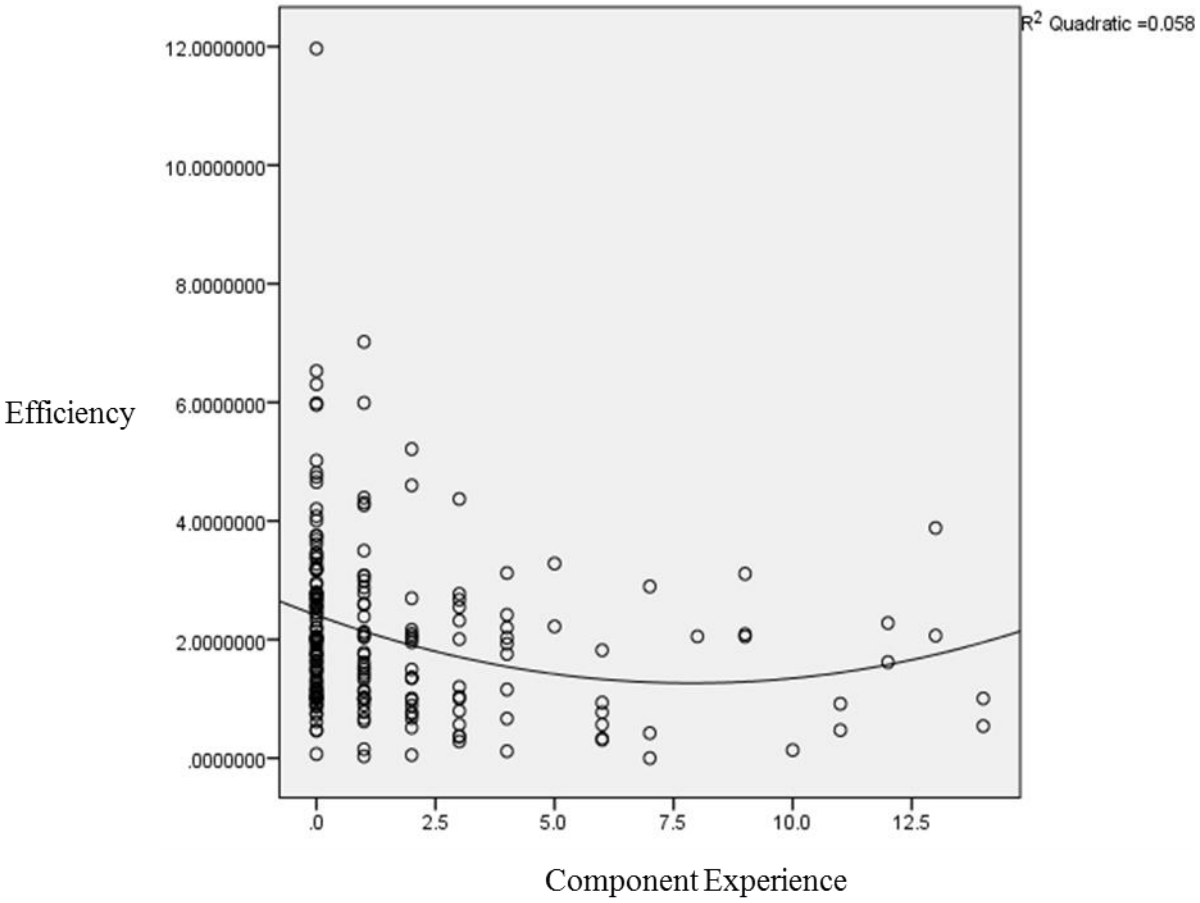
Prior studies have found curvilinear relationships in product development and manufacturing with firms experiencing diminishing returns to inputs as time progresses (Argote, 1993; Hatch and Mowery, 1998; Schilling et al., 2003; Yelle, 1979). I decided to conduct further analyses of my data to see if some of my independent variables had a curvilinear relationship with the dependent variables, instead of the hypothesized linear relationships. These models are included in Tables 5.3 and 5.4.

In table 5.3, market niche experience and platform experience have statistically significant squared terms in Models 1 and 3 of panel A; however these findings are not found in panel B. However, these curvilinear relationships are not found in subsequent models, suggesting

that multicollinearity between the variables may be obfuscating a curvilinear relationship. Therefore, there is limited support for a curvilinear relationship.

When efficiency is regressed on squared independent variables in Table 5.4, component experience, platform experience, and general product development experience all display curvilinear relationships in panel A. Platform and general product development experience are not significant in the final models, though this is most likely due to the high level of multicollinearity between these variables. Component experience has a curvilinear relationship at the p<.1 level in panels A and B. I have plotted this relationship in Figure 5.3. This figure suggests that the time it takes to develop a game decreases at a decreasing rate.

Figure 5.3 Plot of Component Experience and Efficiency with Curvilinear Line



In a further effort to explain the determinants of firm performance, I also conducted analyses to examine the performance implications of effective product development capabilities. I use the total global sales of a game, in units, for each game in my sample set on the Xbox 360 and PlayStation 3 as my dependent variable reflecting firm performance. This data was obtained from VGChartz.com which independently publishes game sales data. I used the average MetaCritic score of the Xbox360 and PlayStation 3 versions of the game to reflect the effectiveness of product development capabilities, and I controlled for two other key factors. First, I included the average number of critics that rated the game for MetaCritic as a measure of public knowledge of the game. Second, I used an indicator variable to measure whether or not the game was released on both the Xbox360 and PlayStation 3, with dual platform release denoted with a 1 and single platform release a zero. The platform information was included in order to control for the potential consumer base for the game; a game released on a single platform would not be able to sell as many copies as a game available on both platforms.

The correlations and descriptive statistics for these variables are displayed in Table 5.5. Effectiveness has multicollinearity with the number of critics, which is not surprising since high quality games will be reviewed more often. Table 5.7 below displays a single regression model with the global sales of a game regressed against the number of critics that reviewed the game, the quality of the game, and if the game was released on all platforms. Standardized beta coefficients are reported in parentheses. Effectiveness is a significant predictor of sales in Models 1 and 3. The number of critics and development for both platforms are also significant predictors of total global sales. Because effectiveness and number of critics is correlated r=.62, when both variables are entered into model 3 the R and R^2 of the model does not increase a great deal compared to models 1 and 2. Substantively, the beta coefficient of effectiveness is .05 in

Model 3 which suggests that one point increase in MetaCritic score will result in 50,000 more units sold of a game. Therefore, effectiveness is shown to be both a statistical and substantive effect on the sales of a game, which helps to validate the use of MetaCritic scores.

Table 5.5: Descriptive Statistics and Correlations for Firm Performance Analysis

	Mean	Std. Dev.	N	1	2	3
1.Total Sales	1.19	2.50	914			
2. Number of Critics	40.27	21.55	914	0.42**		
3. Effectiveness	68.65	14.71	914	0.44**	0.62**	
4. Both Platforms	0.61	0.49	914	0.14**	-0.09**	0.03

** Correlation is significant at the 0.01 level (2-tailed)

Table 5.6: Regression of Total Unit Sales

	Model 1	Model 2	Model 3
Constant	-3.91**	-1.42**	-3.648**
Effectiveness	.07**		.05 (.26)**
Number of Critics		.05**	.032 (.27)**
Both Platforms		.92**	.80 (.16)**
N	914	914	914
R	0.437	0.458	0.502
R^2	0.191	0.21	0.252
Adjusted R^2	0.19	0.208	0.25

** Correlation is significant at the 0.01 level (2-tailed)

Lastly, I wanted to see if additional experience in one platform over the other (Xbox360 vs. PlayStation 3) provided increased effectiveness in the firm's product development capabilities for that platform. To test this, for each game that was released on both consoles I subtracted the MetaCritic score for the PlayStation 3 version from the Xbox 360 version. I also subtracted the firm's experience with the PlayStation 3 platform from the firm's experience with

the Xbox360 platform. Since I only have two variables, OLS regression results would be the same as the pairwise correlation, and therefore I ran a correlation between the variables. I found that the variables were correlated at $r = .12$ which made the relationship statistically significant at the $p < .05$ level with an N of 379. This suggests that increased experience with one platform over another may increase the effectiveness of the firm's product development capabilities for that platform even when the firm develops a product for multiple platforms.

5.4 Conclusion

The results of the analyses do not support the majority of the hypotheses of this dissertation. Table 5.7 summarizes the tested relationships between variables. This dissertation offers few answers to the research questions I address regarding the individual and joint effects of experience and relational resources on a firm's product development capabilities, but the lack of connections between some of my key variables may provide insights into product development in the gaming industry. Although multicollinearity among the firm experience variables provides one possible reason for the lack of support for the hypotheses, I will discuss other reasons for the disjuncture between the hypotheses and data in the Chapter Six.

Table 5.7: Summary of Results for Hypotheses

Hypothesis	DV	IV	Result	Notes
1	Effectiveness	Market Experience	Not Supported	
2a	Effectiveness	Component Experience	Not Supported	
2b	Efficiency	Component Experience	Supported	Robust Curvillinear Relationship
3a	Effectiveness	Platform Experience	Not Supported	
3b	Efficiency	Platform Experience	Not Supported	Non-Robust Curvillinear Relationship
4	Efficiency	Total Experience	Limited Support	Initial improvement in efficiency
5	Efficiency	Platform Alliance	Not Supported	Non-Robust Curvillinear Relationship
6a	Effectiveness	Breath of Relational Resources	Not Supported	
6b	Efficiency	Depth of Relational Resources	Not Supported	
7a	Effectiveness	Market Exp * Depth of RR	Not Supported	
7b	Effectiveness	Component Exp * Depth of RR	Not Supported	
7c	Efficiency	Platform Exp * Platform Alliance	Not Supported	

6.0 DISCUSSION, IMPLICATIONS & CONCLUSION

6.1 Introduction

In this dissertation, I examined the three basic research questions. First, how do different types of product development experience influence a firm's product development capabilities? Second, how do relational resources pertinent to product development influence a firm's product development capabilities? And third, how do experience and relational resources interact to influence a firm's product development capabilities? As discussed in my literature review, firm level product development capabilities have been shown to be an important antecedent to many firm outcomes including profitability (Kroll et al., 1999). In this dissertation I examined my research questions in the context of the videogame development industry. This chapter will discuss the results of the dissertation. First I will analyze the results from Chapter Five and offer potential explanations for the lack of consistency between the theory presented in Chapter Three and the data analysis results. Then I will address potential directions for future research with the variables that are specific to the videogame development industry. Finally, I will expand the discussion to include more generalized applications of my findings.

6.2 The Role of Experience in Product Development

The first research question of this dissertation asks how different types of experience influence a firm's product development capabilities. My first hypothesis proposes that prior firm level market experience is positively related to the effectiveness of the firm's product. This relationship is not supported in the data analysis, which suggests that new firms are able to create highly desirable products. An alternative hypothesis may be that the creative director's experience is more important to a firm's product development capabilities than the experience of the firm itself. This may occur because the creative director is making the most important

decisions regarding the content of the product and his or her previous experience improves decision making. If this alternative hypothesis is accurate, a firm's mission should be to attract and retain highly qualified people, because their prior market experience is more important than the firm's in terms of increasing the firm's product development capabilities.

One of the most unexpected results from this dissertation was that prior experience with a component technology, the game engine in this dissertation, hurt the effectiveness of a firm's product development capabilities. This finding is unexpected because prior studies suggest that technological experience aids a firm's success (Nerkar & Roberts, 2004). Therefore, Hypothesis 2a predicted that prior experience with critical product components would provide the firm more knowledge of how to maximize those components' abilities, ultimately creating a more desirable product. The data analysis results suggest this is incorrect, and that prior experience with a component *reduces* the effectiveness of the firm's product development capabilities. This result may be unique to the video game development industry, or to the specific sample of the industry analyzed, because most of the firms in the data sample are small and work on a single game at a time. It takes approximately two years, per the descriptive statistics, to produce a game product. When a firm uses a component in game development, that technology is at least two years old by the time the game is released. If a firm continues to use the same technology (in this analysis, game engine) in a second iteration of product development, the firm may be using less effective technology than its competitors, causing the product to be less desirable. However, the regression results of efficiency on component experience does show that re-using components leads to savings in time to develop a game. Therefore, there is a trade-off in terms of the quality of the product produced (effectiveness) compared to the speed in which it is produced (efficiency).

I initially proposed in Hypothesis 3a that prior experience with a specific platform would provide the firm with knowledge of how to maximize that platform's capabilities, resulting in increased effectiveness of the firm's product development capabilities. Prior platform experience had positive bivariate correlations with effectiveness and demonstrated a robust linear relationship with effectiveness until the control variables were included in panel A. In addition, there is some support that the relationship between platform experience and effectiveness is curvilinear and not linear. There are two theoretical reasons why this finding was not more robust. First, perhaps prior knowledge of the platform is more important at the individual level, particularly the people coding the game for a platform and not important at the firm level. Because the videogame industry experiences high employee turnover (Alexander, 2010), firm level platform experience may not be as important as experience that the individual programmers have. However this would not explain why efficiency is influenced at the firm level whereas effectiveness is not. A second possible explanation is that in the videogame production industry, firms are developing products for platforms that are technologically static over a period of time (several years) and that no firm has an advantage over another in developing complementary goods for the platform. Furthermore, no game studio has a competitive advantage over another in terms of creating highly effective products since the platform is not rare (Barney, 1991). This could explain why experience with the platform does not aid a firm's ability to make effective products since all firm developing for a platform are familiar with and constrained by the platform's capabilities. Regarding efficiency, platform experience did not display significant bivariate correlations in either panel A or B. However, in Model 3, panel A, of Table 5.4 there is evidence to suggest that platform experience may have curvilinear relationship with efficiency. However, this relationship is not robust in subsequent models in panel A, nor present in panel B.

General product development experience had a U-shaped relationship with the efficiency of a firm's product development capabilities in panel A but not B in table 5.4. This suggests that there are initially some gains in efficiency through more experience in game development, though this relationship is not robust in subsequent models. As shown in Figure 5.2, these gains tend to be removed, and the time it takes to produce a game, when a firm has a history of producing more than 100 games. Whether this loss of efficiency is due to a threshold of experience the firm reaches at about 100 games and the loss of efficiency being an artefact of quadratic equation that best fits the model, or firms that have over 100 games of experience tend to produce multiple games at once which may reduce the efficiency of an individual product's development, is unclear. Further, this curvilinear result does not remain statistically significant in the final regression model, though that is most likely due to multicollinearity with other experience variables.

6.3 The Role of Relational Resources in Product Development

The breadth of relational resources did not influence the effectiveness of a firm's product development capabilities. This is an interesting finding because a wealth of studies suggest that relational resources have a positive effect on product development (Powell; 1996; von Hippel; 1988; Dyer & Nobeoka; 2000). One reason for this finding may be due to the way I measured the breadth of relational resources; by aggregating all types of relational resources (co-developers, sister studios, outsourced firms) into one measure for breadth and depth, I may have eliminated the measure's ability to reflect more specific types of knowledge transfer which may influence a firm's routines and capabilities. Since this dissertation examines product development theory at an aggregated level, I created an aggregate measure and tested Hypothesis 6a at that level.

However, there may be unique relationships within the different types of relationships a game developer has, and these types of relationships should be examined individually in future studies in order to better understand the nuances of this effect.

Aggregating relational resources may have also obscured the effects particular co-developer relationships might have on the efficiency of a firm's product development capabilities. Hypothesis 6b predicted that longer relationships would increase product development efficiency, but this was not supported by the results of the data analysis. Separating the specific experience relationships between co-developers, sister studios, and outsourced firms may provide unique insights in future studies.

6.4 The Interplay between Experience and Relational Resources in Product Development

The interaction between component experience and depth of experience with co-developers had a significant effect on the effectiveness of a firm's product development capabilities. However, Hypothesis 7b was not supported. The data suggests that both firms with no prior experience with product components and firms with a lot of prior experience with those components had highly effective product development capabilities as the length of co-developer experience increased. However, firms with only a single prior experience with a product component had less effective product development capabilities even as experience with their co-developers increased. The most experienced firms would be studios that can rapidly release games before component technology becomes obsolete. These studios represent the largest studios such as Electronic Arts or Capcom, who release dozens of games a year, and therefore gain a lot of component experience in a short period of time. These firms also have a lot of human and financial resources they can devote to a product's development, as well as

longstanding co-developer relationships. Therefore, the high component experience group may reflect a sub-set of large firms with a combination of resources that increases the effectiveness of their product development capabilities, which may skew the results

6.5 Future Research

I have highlighted several avenues for future research where I believe significant contributions can be added to the literature. Areas particularly relevant to the questions examined in this dissertation are relational resources and firm vs. individual experience. For the videogame development industry, the effects of a relationship with a platform owner and the effects of relationships among network of firms within the industry can be avenues for further inquiry. For example, since I aggregated the breadth and depth measures for the types of relational resources in this dissertation, future research could more specifically hypothesize different types of relationships between co-developers, sister studios, and outsourced firms. Each type of relationship may provide something unique to the firm's product development capabilities. For instance, sister studios may not aid the effectiveness of a focal studio's product development capabilities since both studios are owned by a common parent. However, a sister studio may make the development of a product more efficient because they are able to concurrently take on some functions of the game's development. Future research could theorize about the effects of specific relational resources on a firm's product development capabilities.

Second, important contributions can be made by delineating between the potentially different effects that individuals and firms have on the desirability of a product and the speed in which that product is developed. Recent research has shown that key people can be critical to the development of new ideas and patents (Rothaermel, 2007). It would be interesting to delineate

whether or not it is a firm's experience in a market niche or the creative director's experience in the market niche that influences the effectiveness of a product. I attempted to control for individual level experience in this dissertation by including the average number of years in the industry for the creative director and executive producer in my models. However, more nuanced measures of specific individuals and their specific experience with market niches, components, and platforms could lead to critical contributions in the product development literature.

Third, it was found that there was no relationship between having the platform owner as a relational resource and the efficiency of the firm's product development. However, an examination of Table 5.2's correlation matrix shows that there is a pair-wise correlation of .22 between platform relationship and the effectiveness of a firm's product development capabilities. Future studies could try to explain why such a relationship increases the effectiveness of the firm's products and test this relationship with a new data set.

It is interesting to note that the control variable firm age is a significant predictor of effectiveness in the fully specific model. This suggests that the age of the firm contributes to the effectiveness of a firm's product development capabilities in a way that various types of experience does not. Future research may attempt to explain how and why firm age influence the effectiveness of a firm's product development capabilities beyond the experience the firm has in various aspects of product development (e.g., market niche, component and platform).

More broadly, the videogame industry provides a rich dataset that can examine networks of firms and people within those firms. Mollick's (2012) study examined the influence of individuals vs. firms on firm performance, but the extensive network of game studios, their parent companies, and the publishers that market and distribute game products provide a substantial dataset for a more sophisticated analysis that can examine the product development

capabilities of firms as well as the determinants of firm performance. A holistic multilevel industry examination can include relationships between individuals, content creating firms, platform owners, and content distributors/marketers, which would provide understanding of industry behaviors valuable to the strategic management literature.

Finally, it may be important to control for a firm's strategy in future research. Some videogame developers specialize in obtaining licenses and developing games from movie content. Some of these specific developers have a great deal of market niche, platform, and general product development experience. However, game development time in these situations is tightly constrained by the movie's development and release schedule, which may negatively influence the quality of the product. Therefore, firm strategy with regard to which types of games or market niches it wants to develop for may play an important role in determining the firm's product development efficiency or effectiveness, and therefore may merit consideration in future studies.

6.6 Conclusion

This dissertation attempts to explain how different types of experience and relational resources individually and jointly influence a firm's product development capabilities. Using videogame developers as my sample of firms, I found that firm level experience has no impact on the effectiveness of a firm's product development capabilities, but some types of experience do aid the efficiency of the firm's product development capabilities. Relationships with a platform owner did not enhance the efficiency of a firm's product development capabilities; though there is correlational evidence to suggest it may influence the effectiveness of the firm's product development capabilities. Working with more outside developers had no effect on the

effectiveness of the firm's product development capabilities, and increased experience with those outside developers did not aid the focal firm's efficiency. Finally, I was unable to support any of my hypothesized interaction effects.

This dissertation raises more questions than it answers. Understanding why most of the hypotheses were not supported in the context of the videogame industry is a motive for future research. As discussed in this chapter, further refinement of measures and theory may elicit new insights into how experience and relational resources influence the product development capabilities of firms that produce complementary products for platform based technologies.

REFERENCES

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly. 45*(3) 425–455.

Alexander, L. (2010). Analysis: Is The Game Industry A Happy Place? Retrieved on April 2, 2014 from http://www.gamasutra.com/view/news/29292/Analysis_Is_The_Game_Industry_A_Happy_Place.php

Amit, R., & Schoemaker, P. H. (1993). Strategic assets and organizational rent. *Strategic Management Journal, 14*(1), 33-46.

Anderson, E. W., Fornell, C., & Mazvancheryl, S. K. (2004). Customer satisfaction and shareholder value. *Journal of Marketing, 68*(4) 172–185.

Argote, L. (1993). Group and organizational learning curves: Individual, system and environmental components. *British Journal of Social Psychology, 32,* 31–52.

Argote, L. (1999). *Organizational learning: Creating, retaining and transferring knowledge.* Boston, MA: Kluwer Academic.

Argote, L., Beckman, S.L., & Epple, D. (1990). The persistence and transfer of learning in industrial settings. *Management Science, 36*(2), 140–154.

Argote, L., & Epple, D. (1990). Learning curves in manufacturing. *Science, 247*(4945), 920–924.

Arrow, K.J. (1962). The economic implications of learning by doing. *Review of Economic Studies, 29,* 166–170.

Asanuma, B. (1989). Manufacturer-supplier relationships in Japan and the concept of relation-specific skill. *Journal of the Japanese and International Economies, 3,* 1-30.

Barney, J. (1991). Firm Resources and Sustained Competitive Advantage. *Journal Of Management, 17*(1), 99.

Beck, K., Beedle, M., Bennekum, A.V., Cockburn, A., Cunningham, W., Fowler, M. … Thomas, D. (2001). *Manifesto for Agile Software Development*. Retrieved from http://agilemanifesto.org/principles.html.

Becker, G. S. (1964). *Human capital*. New York, NY: Columbia University Press.

Bharadwaj, S.G. & Menon, A. (1993). Determinants of success in service industries: A PIMS-based empirical investigation. *Journal of Services Marketing, 7*(4), 19–40.

Bhaskaran, S. R., & Krishnan, V.V. (2009). Effort, Revenue, And Cost Sharing Mechanisms For Collaborative New Product Development. *Management Science, 55*(7), 1152-1169.

Bhattacherjee, A. (2001). Understanding information systems continuance: An expectation-confirmation model. *MIS Quarterly. 25*(3), 351–370.

Bower, J. L., & Christensen, C.M. (1995). Disruptive Technologies: Catching the Wave. *Harvard Business Review, 73*(1), 43-53.

Bowman, D., & Gatignon, H. (1996). Order Of Entry As A Moderator Of The Effect Of The Marketing Mix On Market Share. *Marketing Science, 15*(3), 222.

Brown, S. L. & Eisenhardt, K.M. (1995). Product Development: Past Research, Present Findings, And Future Directions. *Academy Of Management Review, 20*(2), 343-378.

Buzzell, R. D. & Gale, B. T. (1987). *The PIMS Principles: Linking Strategy to Performance*. Free Press, New York.

Carpenter, G.S. & Nakamoto, K. (1989), Consumer Preference Formation And Pioneering Advantage. *Journal Of Marketing Research, 26,* 285-98.

Chou, C., & Shy, O. (1990). Network effect without network externalities. *International Journal Of Industrial Organization, 8*(2), 259.

Christensen, C. M. (1992). Exploring the limits of technology s-curve. Part I: Component technologies. *Production and Operations Management, 1*(4), 334-357.
Christensen, C. M. (1993). Molding the Impossible: The NYPRO/Vistakon Disposable Contact Lens Project. *Harvard Business School Case.* 9-642-062.
Christensen, C. M. (1997). We've Got Rhythm! Medtronic Corporation's Cardiac Pacemaker Business. *Harvard Business School Case*. 9-698-004.
Church, J., & Gandal, N. (1992). Network effects, software provision, and standardization. *Journal Of Industrial Economics, 40*(1), 85-103.
Church, J., & Gandal, N. (1993). Complementary network externalities and technological adoption. *International Journal Of Industrial Organization, 11*(2), 239.
Clark, K.B., & Takahiro Fujimoto (1991). Product Development Performance: Strategy, Organization, and Management in the World Auto Industry. Boston: Harvard Business School Press.
Coase, R.H. (1937). The Nature of the Firm. *Economica, 4*, 386-405.
Cohen J. (1988). *Statistical Power Analysis for the Behavioral Sciences (second ed*.). Lawrence Erlbaum Associates: Hillsdale, New Jersey.
Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: the two faces of R&D. *Economic Journal, 99*(397), 569-596.
Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly, 35*, 128-152.
Cooper, R. G. (1979). The Dimensions Of Industrial New Product Success And Failure. *Journal of Marketing, 43*, 93-103.
Cronin, J. J., Jr., Brady, M. K., & Hult, G.T.M. (2000). Assessing the effects of quality, value, and customer satisfaction on consumer behavioral intentions in service environments. *Journal of Retailing 76*(2), 193–218.
Dacko, S. G., Liu, B. S., Sudharshan, D., & Furrer, O. (2008). Dynamic capabilities to match multiple product generations and market rhythm. *European Journal of Innovation Management, 11*(4), 441-471.
Davis, F. D. (1989). Perceived usefulness, perceived ease of use and user acceptance of information technology. *MIS Quarterly. 13*(3), 319–340.
Dosi, G., Nelson, R. R., & Winter, S. G. (2000). Introduction: The Nature and Dynamics of Organizational Capabilities. Nature & Dynamics of Organizational Capabilities.
Dougherty, D. (1990). Understanding New Markets For New Products. *Strategic Management Journal, 11*, 59-78.
Dyer, J. H. (1996). Specialized supplier networks as a source of competitive advantage: Evidence from the auto industry. *Strategic Management Journal, 17*, 271-292
Dyer, J. H., & Nobeoka, K. (2000). Creating and managing a high-performance knowledge-sharing network: the Toyota case. *Strategic Management Journal, 21*(3), 345.
Dyer, J., & Singh, H. (1998). The relational view: Cooperative strategies and sources of interorganizational competitive advantage. *Academy of Management Review, 23*(4), 660-679.
Economides, N. (1996). The Economics Of Networks. *International Journal Of Industrial Organization, 14*(6), 673.
Eggers, J.P. (2012). All experience is not created equal: Learning, Adapting, and focusing in product portfolio management. *Strategic Management Journal, 33*, 315-335.

Eggers, J. P., & Kaplan, S. (2013). Cognition And Capabilities: A Multi-Level Perspective. *The Academy Of Management Annals,7*(1), 293.
Evans, D. S. (2003). The Antitrust Economics of Multi-Sided Platform Markets. *Yale Journal On Regulation, 20*(2), 325.
Evans, J.R. & Lindsay, W.M. (2002). *The Management and Control of Quality*. Cincinnati: South-Western.
Farrell, J., & Saloner, G. (1985). Standardization, compatibility, and innovation. *RAND Journal of Economics, 16*(1), 70-83.
Fornell, C., Johnson, M. D., Anderson, E.W., Cha, J., & Bryant, B. E. (1996). The American customer satisfaction index: Nature, purpose, and findings. *Journal of Marketing, 60*(4) 7–18.
Foss, N. J. (1996). Knowledge-based Approaches to the Theory of the Firm: Some Critical Comments. *Organization Science, 7*(5), 470-476.
Gao, J.Z., Tsao, H.S.J., & Wu, J. (2003). *Testing and Quality Assurance for component-based software.* Artech House Inc. Norwood, MA.
Gertsmann, J. (Producer). (2014, March 18). *Giant Bombcast* (Audio podcast). Retrieved from www.giantbomb.com
Gill, G.K. & Wheelwright, S.C. (1991). Motorola Inc.: Bandit Pager Project (Abridged). *Harvard Business School Case.* 9-692-069.
Gnyawali, D., Fan, W., & Penner, J. (2010). Competitive Actions and Dynamics in the Digital Age: An Empirical Investigation of Social Networking Firms. *Information Systems Research, 21*(3), 594-613.
Grant, R.M. (1996a). Prospering in dynamically-competitive environments: Organizational capability as knowledge integration. *Organization Science, 7*, 375-387.
Grant, R.M. (1996b). Toward A Knowledge-Based Theory Of The Firm. *Strategic Management Journal, 17*, 109-122.
Graves, S.B., & Langowitz, N.S. (1993). Innovative productivity and returns to scale in the pharmaceutical industry. *Strategic Management Journal, 14*(8), 593–605.
Gulati, R., & Sytch, M. (2007). Dependence Asymmetry and Joint Dependence in Interorganizational Relationships: Effects of Embeddedness on a Manufacturer's Performance in Procurement Relationships. *Administrative Science Quarterly, 52*, 32-69.
Haas, M. R., & Hansen, M. T. (2007). Different knowledge, different benefits: toward a productivity perspective on knowledge sharing in organizations. *Strategic Management Journal, 28*(11), 1133-1153.
Hatch, N. W., & Mowery, D. C. (1998). Process innovation and learning by doing in semiconductor manufacturing. *Management Science. 44*(11) 1461-1477.
Hansen, M. T. (1999). The Search-Transfer Problem: The Role of Weak Ties in Sharing Knowledge across Organization Subunits. *Administrative Science Quarterly, 44*(1), 82-111.
Helfat, C., Finkelstein, S., Mitchell, W., Peteraf, M., Singh, H., Teece, D. & Winter, S. (2007). *Dynamic Capabilities: Understanding Strategic Change in Organizations*. Malden, MA: Blackwell.
Helfat, C.E., & Lieberman, M.B. (2002). The birth of capabilities: Market entry and the importance of pre-history. *Industrial and Corporate Change, 11*(4), 725–760.
Helfat, C. E., & Peteraf, M. A. (2003). The dynamic resource-based view: capability lifecycles. *Strategic Management Journal, 24*(10), 997-1010.

Helfat, C. E., & Winter, S. G. (2011). Untangling Dynamic and Operational Capabilities: Strategy for the (N)ever-Changing World. *Strategic Management Journal, 32*(11), 1243-1250.
Henderson, R. M., & Clark, K. B. (1990). Architectural Innovation: The Reconfiguration Of Existing Product Technologies And The Failure Of Established Firms. *Administrative Science Quarterly, 35*(1), 9-30.
Henderson, R., & Cockburn, I. (1994). Measuring competence? Exploring firm effects in pharmaceutical research. *Strategic Management Journal, 15*, 63-84.
Hendricks, K. B. & V. R. Singhal (1996). Quality awards and the market value of the firm: An empirical investigation. *Management Science, 42*(3), pp. 415–436.
Hennart, J. 1988. A transaction cost theory of equity joint ventures. *Strategic Management Journal, 9*, 361–374.
Hoang, H., & Rothaermel, F. T. (2010). Leveraging internal and external experience: exploration, exploitation, and R&D project performance. *Strategic Management Journal, 31*(7), 734-758.
Huston, L., & Sakkab, N. (2006). *Connect and Develop: Inside Proctor and Gamble's New Model for Innovation*. Harvard Business Review.
Huff, L. C., & Robinson, W. T. (1994). Note: The impact of leadtime and years of competitive rivalry on pioneer market share advantages. *Management Science, 40*(10), 1370-1370.
Ju, T.L., Li, C. & Lee, T. (2006). A contingency model for knowledge management capability and innovation. *Journal of Industrial Management & Data Systems,106*(6), 855-877.
Junkunc, M. T., & Eckhardt, J. T. (2009). Technical Specialized Knowledge and Secondary Shares in Initial Public Offerings. *Management Science, 55*(10), 1670-1687.
Kale, P., Singh, K., & Perlmutter, H. (2000). Learning and protection of proprietary assets in strategic alliances: Building relational capital. *Strategic Management Journal, 21*, 217-237.
Katz, M. L., & Shapiro, C. (1985). Network Externalities, Competition, and Compatibility. *American Economic Review, 75*(3), 424.
Katz, M. L., & Shapiro, C. (1986). Technology Adoption in the Presence of Network Externalities. *Journal Of Political Economy, 94*(4), 822-841.
Katz, M. L., & Shapiro, C. (1994). Systems Competition and Network Effects. *Journal Of Economic Perspectives, 8*(2), 93-115.
Kerin, R.A., Varadarajan, P.R. & Peterson, R.A. (1992). First-Mover Advantage: A Synthesis, Conceptual Framework, And Research Propositions. *Journal Of Marketing, 56*(4): 33-52.
Kessler, E.H., Alok, K. & Chakrabarti, A.K. (1996). Innovation Speed: A Conceptual Model of Context, Antecedents, and Outcomes. *Academy of Management Review, 21*(4), 1143–91.
Kogut, B., & Zander, U. (1992). Knowledge Of The Firm, Combinative Capabilities, And The Replication Of Technology. *Organization Science, 3*, 383-397.
Kroll, M., Wright, P., & Heiens, R.A. (1999). The contribution of product quality to competitive advantage: Impacts on systematic variance and unexplained variance in returns. *Strategic Management Journal, 20*(4), 375-384.
Kuzma, A. T. & W. L. Shanklin (1992). How Medium-Market-Share Companies Achieve Superior Profitability. *Journal Of Consumer Marketing, 9* (Winter), 34–49.
Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capacity and interorganizational learning. *Strategic Management Journal, 19*(5), 461.

Lavie, D. (2006). The Competitive Advantage Of Interconnected Firms: An Extension Of The Resource-Based View. *Academy Of Management Review, 31*(3), 638-658.
Leonard-Barton, D. (1992). Core Capabilities and Core Rigidities: A Paradox in Managing New Product Development. *Strategic Management Journal, 13*, 111-125.
Levitt, B. & March, J. G. (1988). Organizational Learning. *Annual Review of Sociology, 14*, 319-340.
Lieberman, M. B. (1987). The Learning Curve, Diffusion, And Competitive Strategy. *Strategic Management Journal, 8*(5), 441-452.
Lieberman, M.B. & Montgomery, D.B. (1988), First-Mover Advantages. *Strategic Management Journal, 9*, 41-58.
Liebowitz, S. J., & Margolis, S. E. (1994). Network Externality: An Uncommon Tragedy. *Journal Of Economic Perspectives, 8*(2), 133-150.
Lim, J., Sharkey, T. W., & Heinrichs, J. H. (2003). New Product Development Practices And Export Involvement: An Initial Inquiry. *International Journal Of Innovation Management, 7*(4), 475-499.
MacCormack, A., Verganti, R., & Iansiti, M. (2001). Developing Products on "Internet Time": The Anatomy of a Flexible Development Process. *Management Science, 47*(1), 133-150.
Macher, J. T., & Boerner, C. S. (2006). Experience and scale and scope economies: trade-offs and performance in development. *Strategic Management Journal, 27*(9), 845-865.
Macher, J. T., & Boerner, C. (2012). Technological development at the boundaries of the firm: a knowledge-based examination in drug development. *Strategic Management Journal, 33*(9), 1016-1036.
Madsen, J. B. (2007). Are there diminishing returns to R&D*? Economics Letters, 95*, 161–166.
Marino, L. & Sarrett, S. (2010). Nintendo's Strategy for the Wii: Good Enough to Beat Xbox 360 and Playstation 3?. Thompson-Strickland-Gamble: The Center for Strategic Management.

Marsh, S. J., & Stock, G. N. (2003). Building Dynamic Capabilities in New Product Development through Intertemporal Integration. *Journal Of Product Innovation Management, 20*(2), 136-148.
McEvily, B., & Zaheer, A. (1999). Bridging ties: A source of firm heterogeneity in competitive capabilities. *Strategic Management Journal, 20*, 1133–1156.
Mesquita, L.F., Anand, J., & Brush, T.H. (2008). Comparing the resource and relational based views: Knowledge transfer and spillover in vertical alliances. *Strategic Management Journal, 29*, 913-941.
Mollick, E. (2012). People And Process, Suits And Innovators: The Role Of Individuals In Firm Performance. *Strategic Management Journal*,*33*(9), 1001-1015.
Moorman, C., & Miner, A. S. (1997). The Impact of Organizational Memory on New Product Performance and Creativity. *Journal Of Marketing Research, 34*(1), 91-106.
Murray, J. Y., & Chao, M. H. (2005). A Cross-Team Framework of International Knowledge Acquisition on New Product Development Capabilities and New Product Market Performance. *Journal Of International Marketing, 13*(3), 54-78.
Nahapiet, J., & Ghoshal, S. 1998. Social Capital, Intellectual Capital, And The Organizational Advantage. *Academy Of Management Review, 23*, 42–266.
Nelson R.R., & Winter S.G. 1982. *An Evolutionary Theory Of The Economic Change*. Harvard University Press: Cambridge, MA.

Nerkar, A., & Roberts, P. W. (2004). Technological and product-market experience and the success of new product introductions in the pharmaceutical industry. *Strategic Management Journal, 25*(8/9), 779-799.
Orland, K. (2012). *Why linking developer bonuses to Metacritic scores should come to an end*. Retrieved from http://arstechnica.com/gaming/2012/03/why-linking-developer-bonuses-to-metacritic-scores-should-come-to-an-end/
Penrose E. (1959). *The Theory of the Growth of the Firm*. Oxford University Press: New York.
Perrone, V., Zaheer, A., & McEvily, B. (2003). Free to Be Trusted? Organizational Constraints on Trust in Boundary Spanners. *Organization Science, 14*(4), 422-439.
Powell, T. C. (1995). Total Quality Management As Competitive Advantage: A Review And Study. *Strategic Management Journal, 16*(1), 15–37.
Powell, W. W. (1996). Inter-organizational collaboration in the biotechnology industry. *Journal of Institutional and Theoretical Economics, 152,* 197-225.
Radford, G.S. (1922). *The Control of Quality in Manufacturing*. Ronald Press Company.
Ramaswami, S. S., K. Srivastava, R. R., & Bhargava, M. M. (2009). Market-based capabilities and financial performance of firms: insights into marketing's contribution to firm value. *Journal Of The Academy Of Marketing Science, 37*(2), 97-116.
Ray, G., Barney, J. B., & Muhanna, W. A. (2004). Capabilities, business processes, and competitive advantage: choosing the dependent variable in empirical tests of the resource-based view. *Strategic Management Journal, 25*(1), 23-37.
Reeves, C.A., & Bednar, D.A. (1994). Defining Quality: Alternatives And Implications. *Academy Of Management Review, 19*(3), 419–445.
Robinson, W. T. (1988). Sources of market pioneer advantages the case of industrial good industry. *Journal of Marketing Research,25*(1), 87-94.
Rochet, J., & Tirole, J. (2003). Platform Competition in Two-Sided Markets. *Journal Of The European Economic Association, 1*(4), 990-1029.
Rochet, J., & Tirole, J. (2006). Two-sided markets: a progress report. *RAND Journal Of Economics, 37*(3), 645-667.
Rohlfs, J. (1974). A theory of interdependent demand for a communications service. *Bell Journal Of Economics & Management Science, 5*(1), 16.
Rothaermel, F. T., & Hess, A. M. (2007). Building Dynamic Capabilities: Innovation Driven By Individual-, Firm-, And Network-Level Effects. *Organization Science, 18*(6), 898-921.
Schilling, M. A., Vidal, P., Ployhart, R. E., & Marangoni, A. (2003). Learning by Doing Something Else: Variation, Relatedness, and the Learning Curve. *Management Science, 49*(1), 39-56.
Schilling, M.A. (2010). *Strategic Management of Technological Innovation*. New York: McGraw Hill/Irwin.
Schultz, T. W. (1961). Investment in human capital. *The American Economic Review, 51*(1), 1-17.
Shapiro C. (1983). Premiums for high quality products as returns to reputations. *Quarterly Journal of Economics 98*, 659–679.
Shewhart, W.A. (1931). Economic control of quality of manufactured product. New York: D. Van Nostrand Company.
Sirmon, D. G., Hitt, M. A., & Ireland, R. (2007). Managing firm resources in dynamic environments to create value: looking inside the black box. *Academy Of Management Review, 32(*1), 273-292.

SpeedTree. (2013). Retrieved February 20, 2013 from http://www.speedtree.com.
Spender, J. C. (1996). Making knowledge the basis of a dynamic theory of the firm. *Strategic Management Journal, 17,* 45-62.
Srivastava, M. K., & Gnyawali, D.R. (2011). When do relational resources matter? Leveraging portfolio technological resources for breakthrough innovation. *Academy of Management Journal, 54*(4), 797-810.
Subramaniam, M., & Venkatraman, N. N. (2001). Determinants of transnational new product development capability: testing the influence of transferring and deploying tacit overseas knowledge. *Strategic Management Journal, 22*(4), 359-378.
Tatikonda, M. V., & Montoya-Weiss, M. M. (2001). Integrating operations and marketing perspectives of product innovation: the influence of organizational process factors and capabilities on development performance. *Management Science, 47*(1), 151.
Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*(7), 509-533.
Tripsas, M., & Gavetti, G. (2000). Capabilities, cognition, and inertia: Evidence from digital imaging. *Strategic Management Journal, 21*(10), 1147-1161.
Urban, G. L., Carter, T., Gaskin, S., & Mucha, Z. (1986). Market share rewards to pioneering brands: An empirical analysis and strategic implications. *Management Science, 32*(6), 645-645.
Uzzi, B. (1997). Social structure and competition in interfirm networks: The paradox of embeddedness. *Administrative Science Quarterly, 42*, 35–67.
Venkatesh, V., M. Morris, G. B. Davis, F. D. Davis. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly. 27*(3) 425–478.
Verona, G. (1999). A Resource-Based View Of Product Development. *Academy Of Management Review, 24*(1), 132-142.
von Hippel, E. (1988). *The sources of innovation*. New York: Oxford University Press.
Wernerfelt, B. (1984). A Resource-based View of the Firm. *Strategic Management Journal, 5*(2), 171-180.
Wikipedia (2014). Game Development. Retrieved on March 21, 2014 from http://en.wikipedia.org/wiki/Video_game_development.
Williamson, O. E. (1985). *The Economic Institutions Of Capitalism*. New York: Free Press.
Wixom, B. H., & Todd, P.A.. (2005). A theoretical integration of user satisfaction and technology acceptance. *Information Systems Research. 16*(1) 85–102.
Yelle, L. E. (1979). The learning curve: Historical review and comprehensive survey. *Decision Sciences, 10*, 302-328.
Zaheer, A., McEvily, B., & Perrone, V. (1998). Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organization Science, 9*(2), 141-159.
Zhu, F., & Iansiti, M. (2012). Entry into platform-based markets. *Strategic Management Journal, 33*(1), 88-106.
Zollo, M., & Reuer, J. J. (2010). Experience Spillovers Across Corporate Development Activities. *Organization Science, 21*(6), 1195-1212.