PhD THESIS DECLARATION

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ABSTRACT

TECHNOLOGICAL CHANGE, LEARNING, AND PRODUCT PERFORMANCE: EVIDENCE FROM THE US VIDEO GAME INDUSTRY

By

Hakan OZALP

In this dissertation I examine the link between technological change, learning, and product innovation & performance. Each study focuses on bringing insights to previous research that only considered the relationship between each of these two topics. First study examines how the link between learning and product development is moderated by technology and industry life cycles. Second study investigates how a technologically superior new product may fail due to increasing learning needs of complementary product providers due to technological change brought by this product introduction. Third study examies how trailblazer products are a source of change in industry dynamics, and represent opportunities of imitative learning for entrants, rather than incumbents. These studies are investigated empirically in the US Video Game Industry, with the data spanning from 1972 to 2011.

I dedicate this work to my family: parents, grandparents, and my brother. You have been my source of vision, courage, truthfulness, and perseverance.

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CONTENTS

CHAPTER 1

GENERAL INTRODUCTION

We know very well that technological change matters (Anderson and Tushman, 1986) – by eroding or strengthening capabilities of firms, it determines which firms survive at the end of the day (Tushman and Anderson, 1990). Similarly, we know well that learning matters (Yelle, 1979). Learning – either through experiencing, or observing and vicariously learning- have been shown to be important for competitive advantage, but even more for survival (Levitt and March, 1988; Ingram and Baum, 1997). On top of these, we also know that products, and their development matter for firms (Brown and Eisenhardt, 1995; Danneels, 2002). Products are a good reflection of what capabilities a firm has (Wernerfelt, 1984), and new product development processes entail an important process for firms to adapt themselves to changing environments (Eisenhardt and Martin, 2000).

What we don't know then? The answer is simple: we don't know fully how these topics are linked with each other. We rarely pay attention that technological change is actually embodied in products. We overlook the fact that what we learned matters as long as it holds in the current context – which could be translated as technological and competitive environment for firms. We also don't pay attention that products themselves – although not all products - could represent an important source of learning – just think about how each smartphone design and user interface converged after the success of IPhone. Or just think hundreds of video games with a mascot character jumping over obstacles, modeled after the Super Mario Brothers.

And, why we should care about this? I think this could be better given in an example. A new product is released to the market, which happens to be a new video game platform and first of its kind in terms of technical functions. This product, representing a significant technological change, creates opportunities for other firms, which happen to develop games for these kind of video game consoles. The firm that introduced the video game platform thinks it will dominate the market – because it has a technologically superior product and video game developers are interested in it. However, what happens is that game developers realize it requires them to invest a lot of time to learn how to handle, and harness this new piece of technology. Learning requirements, when combined with time based competition, creates a disaster recipe, for both sides. A more systematic approach to the combination of technology, product, and learning is certainly required here.

In this dissertation, I present three papers that build on the insight of linking these three important elements. Rather than viewing learning occurring in static environments, I consider learning within the changing industry context. Rather than thinking a product arriving to market as ready to use, I consider learning required to support or use this product. Rather than thinking each product as same, I consider trailblazer products that become an example to learn from and change the industry context itself.

Overview of the Chapters

Chapter 2 sets the tone of the dissertation by looking at the impact of types of experience on product development success contingent on discontinuous technology changes and industry life cycle changes. After discussing the recent developments in the product development research – namely firm-level research that looks at the experience-product development success link, I argue that inconclusive results are due to considering the link between types of experience and success as static. Specifically, I build on industry evolution literature, and bring insights from that literature on the firm-level learning research on product development to clarify the contingent impact of each type of experience. In doing so, I also contribute to industry evolution literature by finding evidence of less theorized, but often observed late renewal of mature industries – which is termed as “de-maturation” (Abernathy and Clark, 1985). I test my theory by using over 4800 games and the publishers that produced these games for the years 1995-2007.

Chapter 3 looks at settings where technological change and product development is very closely related. These settings, which historically involved standards battles such as VHS vs. Betamax, recently involve competing platforms, which are defined by indirect network effects. Many of these platforms are also technical devices, and they may become a considerable source of technical change. Specifically, I look at the video game platforms, and ask why do they fail. Our existing knowledge would suggest many of these products, being technologically superior, should capture a considerable amount of market share. However, these products end up creating increased learning costs for other firms that produce complementary products for these platforms – essentially eroding the value of the focal platform due to lack of complementary products or lower than expected quality/quantity of such products. I develop this logic conceptually through a qualitative analysis of the US video game console industry for the years 1988-2011.

Chapter 4 combines some of the insights from Chapter 2 and Chapter 3 and builds a theory on how industries are evolving through trailblazer products. It argues why these products are different, and how they affect entry, demand, and product performance dynamics of the market segments they belong to. In contrary to Chapter 3, these trailblazer products, actually provide learning opportunities for other firms to improve their product performance. Yet, this opportunity is related to the ability to imitate this trailblazer product. I argue and find evidence that those firms with no prior experiene in a segment are in a better position to imitate such trailblazer products. I test this theory with population of games released for fifth-generation and sixth-generation video game consoles in US. This study closes the circle started with Chapter 2 – where industry context was changing product performance, now a high performing product changes the industry context.

CHAPTER 2

DEEPER OR WIDER…AND WHEN? INDUSTRY EVOLUTION AND THE IMPACT OF EXPERIENCE IN PRODUCT DEVELOPMENT OUTCOMES

ABSTRACT

A firm's growth and strategic renewal depends on its ability to continually develop successful products. The role of experience is central to explaining why some firms fare better in these efforts than others, and existing research suggests that we must distinguish between breadth and depth of experience. However, empirical results to date have been inconsistent. I argue that one must look at the changing industry context to discern how depth and breadth of experience influence product development performance. I test the effects of depth and breadth of experience contingent on technology life cycle and industry life cycle (i.e., the evolutionary context) in the US Video Game Industry. I find that depth and breadth of experience significantly affect product development performance only when considered together with evolutionary context. Second, my analysis reveals a counter-intuitive increase in the importance of major innovations late in the industry life cycle. I argue that this is evidence of a "de-maturation" stage of the industry life cycle, which is rarely treated formally, but widely observed in many industries.

INTRODUCTION

A central question in management research is how firms can develop successful new products (Clark and Fujimoto, 1991; Dougherty and Hardy, 1996). Earlier research has tended to focus on how to better manage individual product development projects (see reviews from Brown and Eisenhardt, 1995; Shane and Ulrich, 2004); however, recent studies on this topic have taken a firm-level perspective and examined the role of experience. While some of these latter studies have found that experienced firms develop more successful new products (Helfat and Raubitschek, 2000; Danneels, 2002; Holmqvist, 2004), others report null results or a complicated link between experience and new product success (Moorman and Miner, 1997; Mannor, 2009; Nerkar and Roberts, 2004).

Some scholars have suggested to solve this puzzle by analyzing the composition of the overall product development experience of a firm to assess the different *types* of experience that firms accumulate. From this key idea, two types of product development experience emerge (Moorman and Miner, 1997; Nerkar and Roberts, 2004; Mannor, 2009; Eggers, 2012): *breadth* and *depth*. Breadth of experience represents the diversity of a firm's product development experience. For example, a firm that has developed three new products for three different market segments will have a broader experience base than a firm that has developed three new products for one market segment only. Depth of experience represents the amount of product development experience in a specific market segment. Different types of experience create different kinds of capabilities; hence, research needs to distinguish between breadth and depth of product development experience in order to fully appreciate how experience affects product development success.

Although recent studies have contributed substantially to our understanding of the impact of experience on new product success, they have an important limitation: By conceptualizing experience as a static effect, these studies overlook the important across-time variation in the impact of experience, which occurs because of the evolutionary dynamics of industries. This oversight is problematic, because evolution is associated with changes in the keys to success (Gort and Klepper, 1982; Anderson and Tushman, 1990; Agarwal, Sarkar and Echambadi, 2002). Firms face different competitive environments across different time periods, within an industry. For instance, early car industry is a strikingly different environment than contemporary car industry. Consequently, the value of experience at a given point in time will depend on the current state of the industry. Moreover, the relative importance of breadth and depth of experience will depend on the competitive environment at a given point in time. These characteristics suggest that the current inconsistencies in the literature regarding the effect of experience on product development outcomes could be reconciled by including evolutionary change in the analysis.

The leading theoretical framework for addressing this issue is that of industry evolution, which considers the temporally changing competitive environments in industries (Gort and Klepper, 1982; Klepper, 1996; Agarwal et al, 2002). This literature identifies at least two major life cycles associated with evolutionary change: technology life cycle, which is the time span between a new technology's emergence and its decline (Anderson and Tushman, 1990), and industry life cycle, which is the time span between an industry's emergence and its decline (Gort and Klepper, 1982; Klepper, 1996). A common theme in this literature is the discontinuous change in competitive conditions at particular points within each life cycle (Agarwal et al., 2002), which provides a suitable approach to examine the changing effect of experience on product development success across time. Therefore, my research question is: "How do technological and industry life cycle changes affect the relationship between breadth and depth of experience and product development success?"

To test my ideas, I estimated the determinants of sales of video games released by publishers in the US Video Game Industry between 1995 and 2007. This is a suitable research context, for several reasons. First, it is an industry in which product development projects and learning from them play critical roles. Second, the industry has passed through multiple technology life cycles, in the form of console generations, and it has matured through the industry life cycle, mainly due to the increasing cost of developing games (Tschang, 2007). Third, the availability of multiple segments, in the form of genres, allows a researcher to measure firms' breadth and depth of product development experience. The results offer two interesting findings. First, the impact of experience on product development success is largely dependent on the point in time of technology and industry life cycles. Neither breadth nor depth of experience affects product development performance without consideration of these industry evolutionary forces. Deeper experiences improve product development performance in the mature (i.e., later half of the cycle) stage of technology and industry life cycles. Broader experiences improve product development performance in the growth (i.e., first half of the cycle) stage of the technology life cycle. Second, I find a counter-intuitive increase in the importance of breadth of experience in the last stage of industry life cycle. Some industry life cycle studies identify an industry stage of rejuvenation called "de-maturation". Based on these studies, I define the *de-maturation stage* as the period in the industry life cycle that comes well along into the mature stage and is associated with an unexpected sharp rise in innovation (Klepper, 1997)[1]. My findings reveal the importance of this stage of industry evolution, which has often been overlooked in the extant literature (for exceptions, see Klepper, 1997; Adner and Levinthal, 2001; Tripsas, 2008).

My research contributes to research into the product development performance impact of a firm's experience in several ways (Nerkar and Roberts, 2004; Eggers, 2012). First, I clarify the link between firm experience and product development success by showing the strong moderating role played by evolutionary forces (i.e., technology and industry life cycles). Second, I clarify when each type of experience will be more or less relevant to improving product development outcomes, by separately assessing the impact of evolutionary forces on breadth and depth of experience. Third, the study makes an additional contribution to the industry evolution literature by testing the moderating impact of industry life cycle on performance outcomes. By doing so, it reveals a stage of the industry life cycle which follows the mature stage, but which shares characteristics of both growth and mature stages. Klepper (1997: 174-175) states that: "The PLC[2] does a good job of describing the stages of industry evolution through the formative eras of many industries. But after the number of firms stabilizes and firm market shares settle down, there appear to be fairly regular developments that are not captured by the PLC… unpredicted facet of the mature stage is that many products appear to experience a sharp rise in innovation in this stage…" The current study adds another piece of evidence for Klepper's (1997) de-maturation phase of the industry life cycle.

THEORY AND HYPOTHESES

The objective of the current research is to extend the cluster of studies looking at product development success, by taking a firm-level perspective of learning and capability development. Previous research on this topic has shown mixed results. Existing research based

[1] Extant research has suggested that a dramatic change from a stable mature stage to the more innovative de-maturation stage is associated with either a shift in the technology, shift in customer demand, or shock in the competitive environment (e.g., sudden entry of Japanese producers in US car market) (Abernathy and Clark, 1985; Klepper, 1997; Tripsas 2008). Previous research has not identified the prerequisites for exogeneous shifts to trigger the de-maturation stage; however, the evidence suggests that such events are a possible cause. I will later discuss a similar exogeneous change that created a shift in the competitive environment in the Video Game Industry.

[2] Product life cycle. Klepper notes that (p. 148, footnote 1) the terms product and industry life cycles are used interchangeably in the article.

on fieldwork suggests that experience is critical in explaining why some firms do better in product development efforts. For example, the case-based studies of Helfat and Raubitschek (2000) and Daneels (2002) reveal that product development in high-technology firms does not only utilize the existing capabilities of the firm, but helps create new capabilities. Another case study by Holmqvist (2004) examines how firms learn from new product development projects. On the other hand, studies applying statistical tests to large archival databases have revealed either a complicated relationship between experience and new product success, or none at all (Moorman and Miner, 1997; Mannor, 2009; Nerkar and Roberts, 2004; Eggers, 2012). Indeed, these latter studies have suggested that we need to separate the different dimensions of experience in order to explain the relationship; for example, dispersion versus volume of experience (Moorman and Miner, 1997), distal versus proximal experience (Nerkar and Roberts, 2004), and breadth versus depth of experience (Mannor, 2009; Eggers, 2012).

Following this stream of research, I distinguish between breadth and depth of experience. Experience breadth captures the diversity – in terms of different market segments – of a firm's product development experience. Experience depth captures how many prior products the firm has released in the market segment of the focal product. The experience of a firm becomes broader as it develops products for more diverse market segments. It becomes deeper as the firm has more prior developed products in focal market segment.

The organizational learning literature has generally considered that a broad experience base is important for creating a substantial knowledge base (Huber, 1991) and for avoiding knowledge over-specialization (Levinthal and March, 1993). Empirical work has supported these ideas and found that there are two distinct advantages to a broader experience base. First, a broader experience base increases the number of different knowledge elements available for recombination (Fleming, 2001). As recombination is the source of most innovation (Schumpeter, 1934), the availability of more unique knowledge elements provides more possibilities to innovate (Ahuja and Katila, 2002). Second, broader experience develops higher order capabilities which make the firm more flexible. The idea is that, as firms enter new market segments to broaden their experience bases, they adapt to these new segments by changing their capabilities. As the firm further broadens, it learns how to make such changes and, consequentially, how to enter more new market segments. In essence, firms learn to change themselves by broadening their experiences (Amburgey, Kelly, and Barnett, 1993; King and Tucci, 2002). Eggers (2012) shows that the broader the firm's experience in terms of market segments, the better it becomes in developing products to enter other new market segments. Similarly, Chen, Williams, and Agarwal (2012) show that diversifying entrants outperform *de novo* firms in the telecommunications industry, because the entrants' broader experience base (cross-industry entry) makes them better able to deal with the major technical changes and inertial challenges brought on by firm growth. Clearly, breadth of experience is beneficial; but some studies have noted that it can come at the expense of efficiency (Eggers, 2012). Katila and Ahuja (2002) show that a very broad experience base leads to fewer new innovations, because of the increasing costs associated with managing a diverse knowledge base.

Depth of experience is closely related to learning-by-doing (Arrow, 1962; Yelle, 1979). As a firm deepens its experience in a segment, its knowledge related to that segment increases, which in turn helps it to perform better. Helfat and Lieberman (2002) point out that knowledge that develops with such experience is related to customer needs and the underlying technology of the specific market segment. As a firm's specific knowledge increases, it comes to better understand the relationships between the different components that form a product and how customer needs could be translated in new products (Zirger and Maidique, 1990; Fleming, 2001). On the other hand, the learning literature has long argued that too much experience depth may lead to competence traps (Levitt and March, 1988) or may turn core capabilities into core rigidities (Leonard-Barton, 1992). Empirical studies also show that firms that rely on deep experiences are less innovative and less successful in their innovations (Ahuja and Lampert, 2001; Ahuja and Katila, 2002).[3]

Clearly, distinguishing between depth and breadth of experience is an important step in fully understanding the link between experience and new product success; however, research has not yet fully explained when firms can benefit from their breadth and depth of experience. Prior work has theorized about the benefits of both types of experience, yet revealed inconsistent findings. Nerkar and Roberts (2004) report that what matters for new product performance is

[3] One can ask whether breadth and depth of experience and exploration–exploitation are the same. There are two important differences between these constructs. First, exploration–exploitation has been considered to be a dichotomy, with a tension between the two. However, breadth and depth of experience are separate dimensions that can be differentiated. "We argue that firms can differentiate themselves not only as to the extent to which they explore new things, but also as to the extent to which they master the old ones. Thus, we extend the unidimensional concept of exploitation versus exploration into a two-dimensional framework." (Katila and Ahuja, 2002). Correlations between experience depth and breadth confirm this theoretical point. Second, breadth and depth of experience is related to a firm's past choices (i.e., experiences) and the firm cannot change its past. Whereas, exploration and exploitation are different strategies that firms can choose at any point in time (Benner and Tushman, 2002).

the combination of broad market and technological experience, rather than depth of experience. Mannor (2009) finds that depth of experience increases the box office revenues of new movies, whereas breadth of experience does not. Eggers (2012) finds that breadth of experience improves the performance of new hedge funds only if the firm has no prior experience in that particular market segment; whereas, prior experience in the market segment (i.e., experience depth) does not increase product performance. In sum, these studies lack a generalizable finding that could predict the impact of experience depth and breadth on new product performance.

I propose that we need a more nuanced view. As industries evolve, firms face different kinds of competitive environments at different time periods. Technological shifts, as well as gradual changes in the industry structure (such as firm concentration and scale), mandate different requirements for developing new products. Prior studies have assumed that the competitive environment is stable within an industry across time, which is questionable. However a central tenet of organizational learning literature is that the value of experience is contingent on the environment in which the firm is competing (Argote and Epple, 1990; Levitt and March, 1988). I seek to advance research on the link between experience and product development performance by considering the two major evolutionary cycles that change the competitive environment of an industry: technology life cycle and industry life cycle.

In the next section I will build hypotheses on the impact of depth and breadth of experience on product development performance, contingent on different stages of the technology life cycle and the industry life cycle. As mentioned above, previous studies have generally considered both breadth and depth of experience to be positively related to product development performance. The extant research has tended to consider only the positive sides of each type of experience and theorized for the positive effect, even though both types of experience do have their downsides. Nevertheless, to be consistent with previous research and to understand the extent to which I can confirm this baseline, I also consider that depth and breadth of experience are both positively related to product development success.

The Value of Breadth and Depth of Experience depends on Evolutionary Changes

The theory of the “product life cycle” first presented by Utterback and Abernathy (1975) and Abernathy and Utterback (1978) motivated several further studies examining industry and technology life cycles. These two related, but different, life cycles rest on similar logic—in early stages, firms compete on alternative “product designs” that differ significantly from each other; for instance early electric and internal-combustion cars. In later stages, the rate of product innovation declines and firms compete in making incremental innovations to well-accepted product designs. The two life cycles have different sources of change: technology life cycles represent the time span between a new technology's emergence and its decline (Anderson and Tushman, 1990); whereas, industry life cycles represent the time span between an industry's emergence and its decline (Gort and Klepper, 1982). Therefore, an industry could have multiple technology life cycles through its industry life cycle.

Technology Life Cycles and Impact of Experience

According to the technology life cycle view, industries are characterized by a cyclical model of technical change. Radical new technologies create discontinuity by dramatically advancing the performance or performance/price frontier and initiating an era of ferment. As explained above, this era of unrest is also often a period of intense market innovation as firms compete with alternative versions of their technological innovation. Entrants bring new knowledge based on the new technology (Gort and Klepper, 1982) and incumbent firms must incorporate this new knowledge in order to compete (Abernathy and Utterback, 1978; Tushman and Anderson, 1986). This knowledge includes technology and customer knowledge, because new technology life cycles bring new customer segments into an industry. (Adner, 2002; Tripsas, 2009). A wave of failures occurs among incumbent firms that do not utilize this new knowledge (Anderson and Tushman, 1990). This era of ferment is then followed by an era of incremental change. Technology stabilizes and firms compete by refining existing designs and making incremental innovations. This cycle repeats itself when another radical innovation comes into the industry.

Broader experience is critical to the success of those firms which explore new design possibilities in the era of ferment, for several reasons. First, as innovation scholars argue, access to a broader experience base is important for coming up with major innovations (Ahuja and Lampert, 2001; Ahuja and Katila, 2002). All else being equal, the broader the experience base, the greater the recombinatorial possibilities (Fleming and Sorenson, 2001; Schilling and Green, 2011). More possibilities translate to more innovation because novelty comes from recombination (Schumpeter, 1975; Fleming, 2001). Second, broader experience provides firms with multiple and varied interpretations of an existing problem (Haunschild and Sullivan, 2002), allowing them to more deeply analyze the contingencies they face (Salvato, 2009). This is an advantage for firms seeking to introduce major innovations into unstable technological environment. Third, broader experiences provide firms with more flexible product development processes. In an era of ferment, firms need to be able to quickly adapt their existing knowledge base. Those with a broader experience base are familiar with this process, since they have done it before when entering new market segments (King and Tucci, 2002; Eggers, 2012).[4]

On the other hand, deeper experience does not provide any benefits in an era of ferment; indeed, it may even be harmful. There are several reasons for this. First, innovation studies have pointed out that deeper experiences, especially at high levels, are related to incremental advances rather than novel or radical innovations (Fleming and Sorenson, 2004; Katila, 2000; Mezias and Glynn, 1993; Schilling, 2005). An era of ferment requires firms to focus on radical innovation; however, deeper experiences may only encourage incremental innovation. Second, deeper experience develops specific technological and customer knowledge in a particular market segment. However, such specialist knowledge can quickly become obsolete during an era of ferment in which underlying technology and customer knowledge change. Third, the learning literature points out that deeper experience could lead to competence traps during times of change (Levitt and March, 1988; Levinthal and March, 1993). This is because firms tend to rely on their previous experiences, even in the face of change (March, 1991). An era of ferment requires firms to utilize new knowledge about technology and customer demands, but deep experience can create inertia. Leonard-Barton (1992) has documented how core knowledge can become “core rigidity” in times of change, and depth of experience can undermine performance.

In summary, broader experience helps the firm successfully compete in an era of ferment by facilitating new combinations for innovation and changing knowledge base configurations. Deeper experience offers less benefit, because the knowledge gained by such experience is made obsolete by technological discontinuity. At extreme cases, deeper experience may undermine the new product success of the firm because it entrenches obsolete knowledge in the face of change. Thus:

Hypothesis 1a: *The positive impact of experience depth on product development performance is negatively moderated by an era of ferment.*

Hypothesis 1b: *The positive impact of experience breadth on product development performance is positively moderated by an era of ferment.*

[4] Another interpretation is that it is less costly for firms with broader experience to change, as they have already done so in order to broaden their experience base.

Industry Life Cycle and and Impact of Experience

Investigations of industry life cycle usually examine the two main phases of growth and maturity (Agarwal et al., 2002). The growth phase of an industry is characterized by "creative destruction" (Schumpeter, 1934) in which entrants with heterogeneous product development capabilities enter the industry (Klepper, 1996). These firms develop distinctive variants of a product, which increases industry innovation rates. In this phase, the new entrants hold the knowledge critical to generating radical innovations (Winter, 1984). Entering firms play a key role in industry evolution, because they are the agents of the change (Gort and Klepper, 1982). Eventually, a shakeout occurs in which firms with higher product development costs exit, triggering the mature phase. This shift occurs because firms with scale advantage are able to innovate more cheaply. After the shakeout, entry becomes infeasible because the remaining incumbents have a cost advantage when it comes to innovation. In the mature phase, firms compete on the basis of cost; therefore, incremental innovations and refinements to existing knowledge take priority over major product innovations.

Some scholars have identified a *de-maturation phase* that occurs well into the mature phase (Abernathy et al., 1983; Klepper, 1997) and is distinguished by a sharp rise in innovation rates (Abernathy and Clark, 1985; Klepper, 1997). For example, Gort and Klepper (1982) studied 46 industries and found that most of them experienced an unexpected surge in patenting well into their mature phase. I follow these studies and define this period in the industry life cycle as the phase following the mature stage that is associated with an unexpected sharp rise in innovation. The de-maturation phase is characterized by a critical demand for innovation, either due to exogenous or endogenous changes in the industry. For example, Tripsas (2008) points out that new customer requirements drove major innovations in the typesetter industry. Similarly, Abernathy and Clark (1985) showed that US car makers dramatically increased their major product innovations after Japanese firms began to enter the US market. It is worth noting that the de-maturation stage is different from the growth stage because, in the former, firms are already large and focused on incremental innovation. As such, this stage has a mix of the attributes of growth and mature phases and both major and incremental innovations are important.

Deeper experience has advantages as industries mature through the life cycle. Mature industries tend to have a set of entrenched practices (Abernathy and Utterback, 1978). These practices require individual firms to compete through incremental innovation, since survival and performance depend on elaborating existing designs or technologies. Such patterns are reflected in firms either competing on cost (Klepper, 1996) or by increasing their R&D expenditures (Klepper, 1997, p.151). In this context, depth of experience is advantageous because the familiarity that comes through developing deep and specific technical and customer knowledge allows a firm to make incremental innovations that keep pace with cost-based competition. Also, deeper experiences tend to make a firm inertial (Levinthal and March, 1993), which in turn makes it very efficient at competing via incremental innovation in a stable and mature industry (Benner and Tushman, 2003). Importance of efficiency and incremental innovations also last in the de-maturity phase as this period is also characterized by ongoing focus on incremental innovations.

On the other hand, broader experience tends to undermine product development success in the mature industry phase because the stable environment offers fewer opportunities and lower returns for any competitively significant changes. As such, the costs of managing a diverse knowledge base could exceed any benefits accrued via innovation (Katila and Ahuja, 2002; Zollo and Winter, 2002; Winter, 2003). Moreover, in the mature phase, the market rewards incremental innovations rather than major innovations. Therefore, the innovations that emerge from a broader experience base may not create value. Second, some firms narrow their experience bases and “specialize on particular products, with resulting high product quality” (Siggelkow, 2003, p.122). When it comes to product innovation, firms with broader experience bases may struggle to compete with these narrow firms. This is because narrow firms have developed inflexible, but specialized, product development processes (Eggers, 2012).

Nevertheless, a broader experience base is advantageous in a de-maturation phase, in which increased demand for innovation opens opportunities to make competitively significant changes. Firms with broader experience bases will have three main advantages in the de-maturation phase, which are similar to those that arise in an era of ferment; namely, greater knowledge base for recombination, multiple interpretations and deeper analysis of contingencies, and more flexible product innovation processes to adapt changes. A combination of these factors allows firms with broader experiences to develop the major innovations required to compete in a de-maturation phase.

In summary, deeper experiences are more advantageous for the firm in mature and de-maturation phases (vs. growth phase), whereas broader experiences are more advantageous in growth and de-maturation phases.

Hypothesis 2a: *The positive impact of experience depth on product development performance is positively moderated by the mature and de-maturation phases of the industry life cycle.*

Hypothesis 2b: *The positive impact of experience breadth on product development performance is negatively moderated by the mature phase and positively moderated by the de-maturation phase of the industry life cycle.*

In conclusion, I have theorized that evolutionary changes will substantially influence the impact of breadth and depth of experience on new product development performance. Furthermore, I have hypothesized that these influences will depend on the type of life cycle considered.

METHODS

Setting: US Video Game Industry

The hypotheses described above need to be tested in a research setting which satisfies several key conditions. First, product development should have a key role in the industry, along with the learning that facilitates this development. Second, there should be clearly identifiable technology and industry life cycles,. Third, the industry must have multiple meaningful and measurable market domains, so that I can gauge breadth and depth of experience. Last, detailed product-level data should be available so that I can build the experience profiles of firms and measure success at the product level.

The Video Game Industry is an excellent setting in which to test how evolutionary changes affect the value of breadth and depth of experience. First, products, and learning from product development experiences, play a central role in this industry. Its firms need to continually develop new products because an average product makes over 80% of its sales in its first 12 months on the market (Dezso et al., 2010). Second, there are clearly identifiable technological life cycles in the form of new console generations. Also, the console game market conforms to expected industry life cycle patterns; that is, a continuous increase in product development costs which eventually triggered a shakeout of firms from the industry. Third, there are multiple game genres, which are distinct from each other in terms of both customer demand and product technology. Last, detailed data is available to quantify the success of individual products and to measure the product development experience profiles of firms in the industry.

There are three key characteristics of this research setting. First, the Video Game Industry is a mix of creative and knowledge-intensive industries that involves both entertainment and innovation (Mollick, 2012). Second, there are two types of organizations in the software side of the industry, which work together to develop products: game developers and game publishers.[5] Game developers are responsible for the creative and technical side of game development. Game publishers are the gatekeepers who finance developers and market and distribute their games. Publishers take a risk when they fund a developer; so they tend to supervise, advise, and collaborate with them along the way. Some run their own in-house "developer studios". Publishers significantly influence a game's likely success by contributing resources to marketing and promotion (Piezunka, 2014). Third, consumer tastes are in constant change, which requires publishers to pursue the right opportunities, based on their previous experiences. Therefore, in this study, I test my hypotheses by considering game publishers, and I adopt various controls and robustness checks to account for developers.

The Video Game Industry experiences technological discontinuities in the form of new generations of console releases (Balland et al., 2012; de Vaan, 2014). On average, a new console generation is released every five years and this presents firms with both opportunities and challenges. On one hand, there are opportunities in that "each transition to new generations of hardware has always been accompanied by the introduction of these new and original game concepts that become defining games for that particular generation" (de Vaan, 2014; p.1670). On the other hand, new generations require publishers to supply developers with new tools and resources, as well as adapt to changing market requirements. More importantly, publishers must respond to changing consumer preferences and consider how their games will be received in both existing and new categories (i.e., genre). Discontinuous technical changes following the release of new generation consoles tend to increase market uncertainty (as well as technical uncertainty) because it take some time for the market to settle on which innovations, or genres, consumers will favor. Even though technological changes are the norm in the Video Game

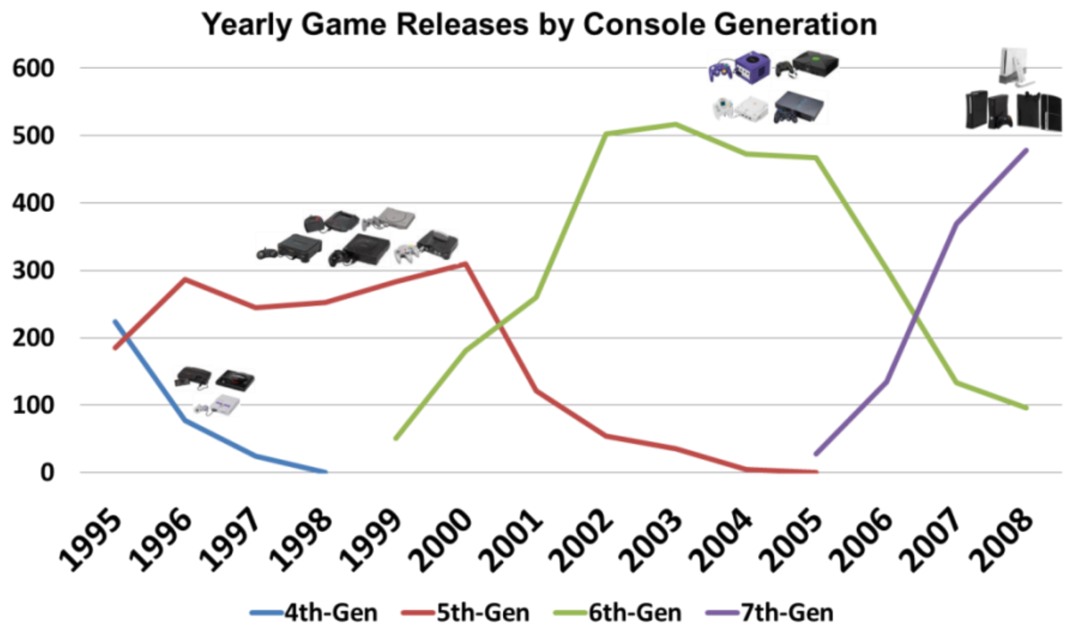
[5] Console owners are organizations which represent the hardware side of the industry. My dataset includes games published by console owners. As a robustness check, I also test my hypotheses excluding games published by console owners and find similar results.

Industry, they still pose a real dilemma for publishers.[6] The following figures illustrate this point.[7]

Figure 1 shows each technological generation and the number of games released per year, in this study. Figure 2 shows that market share shifts quickly between genres (red line), following the release of new consoles (left axis).[8]

FIGURE 1

Game Releases by Year and Technological Generation



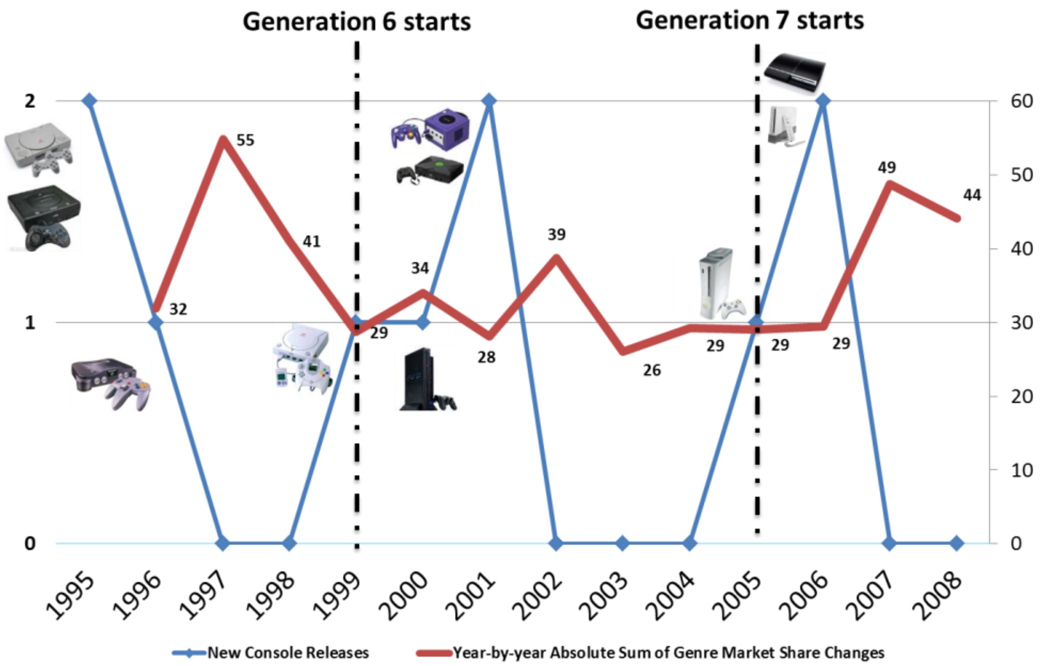
[6] "With target audiences and video game consumption constantly evolving, it is essential for a publisher to correctly anticipate market trends and to choose the proper format for a game. This strategic choice is crucial, given the sums invested." (Ubisoft, 2009)

[7] One could argue that technological discontinuity does not reflect my point, because it has become easier to write games for multiple platforms in recent years. However, such games are written for multiple platforms in the same generation. For a publisher, the challenge of adapting to new genres and market changes remains the same, and even intensifies, as can be seen in Figure 2 after the release of Wii.

[8] These values are calculated using sales data and genre information from NPD research, which I explain in the Methods section.

FIGURE 2

Console Releases and Year-by-Year Absolute Total of Market Share Changes between Industry Genres

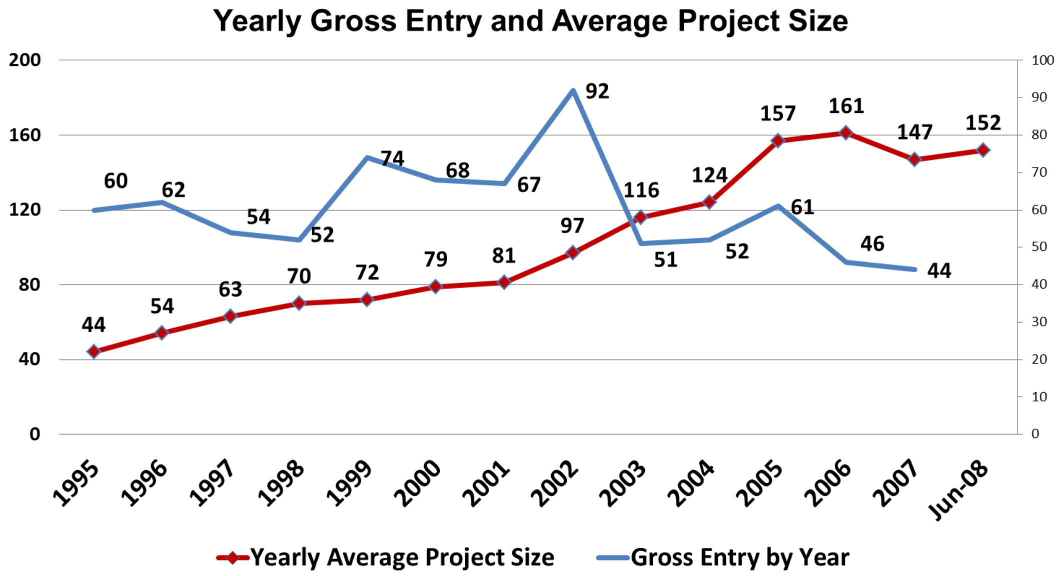


Last, although the Video Game Industry is essentially creative, it has matured over time due to rapidly increasing product development costs. This pattern is consistent with Klepper's (1997) idea that increasing product R&D expenditures (p.151) is an alternative mechanism for industry life cycle changes. The maturing of the industry is best reflected by the mean numbers of people engaged in producing games, because labor represents the largest share of industry R&D costs. Increasing costs have caused a shakeout of firms, a trend which conforms to the typical industry life cycle patterns described by Klepper (1996). Figure 3 shows that the mean number of people engaged in producing games has increased tremendously over time and that gross entry[9] rates (publishers and developers combined) fell after 2002. Tschang (2007) explains that these changes have been coupled with "rationalization" of the industry, which is the predominant focus on business interests or productivity-oriented production processes, usually at the expense of creativity. This trend is consistent with an industry in its mature phase, characterized by incremental process innovation.

[9] Gross entry means total number of firm entries in a given year. Other industry evolution studies (Agarwal and Gort, 1996; Agarwal et al., 2002) have used gross entry numbers to measure industry life cycle phases.

FIGURE 3

Yearly Industry Average Project Size and Firm Gross Entry



Data

I built the dataset for this study from multiple sources; primarily the *MobyGames* website, which is the oldest and largest online video game archive on the Internet (Mollick, 2012; de Vaan, 2014). MobyGames defines its mission as: “To meticulously catalog all relevant information about electronic games on a game-by-game basis and then offer up that information through flexible queries and data mining.” At the time of data collection, MobyGames had information on over 68,000 titles, all voluntarily entered by site users according to a detailed set of data entry instructions. To ensure accuracy, MobyGames requires that all contributed data is peer reviewed. The data include title, platform, publisher, developer, credits, release date, release country, and information on whether a game uses licensed material (e.g., FIFA Soccer). The site also provides detailed game characteristics, which I used as a robustness check, described later in this section.

MobyGames provides publisher (and developer) information for each game; however, it is not able to fully account for parent–subsidiary relationships, mergers and acquisitions, or publisher/developer name changes. For this study, it is crucial that this information be correct to ensure that the main experience variables are calculated correctly and that the past history of a publisher (or developer) is not miscalcuated due to a name change. Therefore, I complemented the publisher and developer information collected from MobyGames with information manually collected from GiantBomb, Wikipedia, official firm websites, and Factiva. To accurately track experience, firms that underwent a name change were associated with a single name. The activities of subsidiary firms were subsumed under the parent company. Firms which started out as independent companies but were then acquired, were treated as an independent firm until acquisition and then subsumed under the parent company.

I collected information on over 68,000 games. From this population, I retained only games released in the US until the end of 2011. İ took this approach because more recently released, lesser-known games may not yet have been entered into the MobyGames site, hence biasing the sample. I also removed games that are bundles of previously released games or re-releases of the same game on different occasions. I excluded games produced for handheld consoles and mobile devices, since they represent a market other than the major game industry, especially in the years of analysis. After these exclusions, there were 25,399 title-platform releases for the years 1972–2011, for personal computer or video game consoles. I actually analyze a subset of this dataset, as explained below; however, I calculated all firm experience variables using this larger (25,399) dataset of personal computer (PC) and game console releases to correctly account for the game development history of each publisher (and developer).

I focus on one segment of this dataset—console games—as opposed to PC games. There are several advantages to examining console games, which make up the majority of sales of the market, in the period under observation. First, clear technological life cycles are observable and measurable in the console games segment, both theoretically and computationally. That is, a new generation of console devices is released every five years on average and is associated with changes in the market (as explained above). Second, it is significantly more resource-intensive to release a game for a console than for a personal computer. This is because publishers need to have a licence agreement in place with the platform owner, which drives up costs and requires higher sales revenue to break even. Thus, our dependent variable—game sales—is a very fitting measure of performance. Third, industry maturation effects are more evident for console games, because there are higher entry barriers for publishing and developing console games compared to PC games. Excluding PC game releases from the data left a dataset of 11,039 title-platform releases.

Finally, this remaining dataset was matched with another dataset of game revenues for the period 1995–2008, for the dependent variable. NPD research tracks the monthly sales data of every console game sold through US retail channels for most major retailers, and projects sales for the rest. Due to our chosen dependent variable, we excluded from the NPD dataset games released before 1995, but tracked in the NPD as of 1995. We also excluded games released after June 2007. Matching these two datasets resulted in a dataset of 4,919 title-platform releases for games released in 1995–2007 for video game consoles. Finally, games released by a publisher in its first year of existence were removed, since these firms have no previous experience (Eggers, 2012). My final dataset consists of 4,852 title-platform releases between January 1995 and June 2007, released by 139 publishers.

NPD research classifies games into genres, each representing distinct market segments for developing, marketing, and consuming games. These genres include story, art development, graphic technology, game mechanics, demand segments, marketing, demographics, and so on. Different capabilities are required to succeed in each genre, similar to movie industry (Shamsie et al., 2009). In total, the NPD dataset distinguishes 54 detailed genres (e.g., Soccer, Tactical Shooter), and 14 aggregrated super-genres (e.g., Sports, Shooter). As I needed to calculate publisher experience since 1995, including that with past games, I matched the NPD genre classifications to the MobyGames game characteristics, as follows. The MobyGames data provides detailed information on each title with up to 102 characteristics, comprising eight main genres (action, adventure, role-playing, simulation, educational, strategy, racing, sports), six perspectives (e.g., 1st person perspective, 3rd person perspective, side scrolling, etc.), and 88 sub-genre characteristics (e.g., shooter, turn-based, etc.). I re-created the NPD genre and super-genre classifications using the MobyGames characteristics. This step provided a concordance rate of 62% for genres and around 90% for super-genres.[10] I used the genre information to measure depth of experience and super-genre information to measure breadth of experience; I also conducted several robustness checks to ensure the results were not driven by any concordance issues.

Variables

Table 1 summarizes the variables used to test my hypotheses.

[10] Concordance between NPD data and MobyGames data genres is over 90% for most of the smaller, specialized genres (e.g., Basketball, Pinball, etc). İt is lower, around 50%, for a few very broad genres that are both similar to each other and not easily distinguished in the MobyGames dataset. These are General Action games vs. Platform games, and Action Racing games vs. Realistic Racing games.

TABLE 1

Variable descriptions

Variables	Description
Dependent variable	
Revenue	Natural logarithm of the revenues generated by a game in the first year after its release (1995 price index converted).
Independent variables	
Experience Breadth	Diversity of product development experience. Calculated as the Herfindahl index, reflecting the diversity of products the firm has developed in the past.
Experience Depth	Total volume of experience the firm has accumulated within the genre of the focal new game release.
Era of Ferment	Dummy = 1 for games released in the years of a technological generation until a year after all consoles for that generation are released.
Mature Phase	Dummy = 1 for games released after 2002.
Maturity	Continuous variable to measure maturity over time rather than as a dummy to separate the industry into two broad periods. Logged yearly average project size at the industry level has been used to measure maturity.
Control variables	
Console Owner	Dummy = 1 if game is published by a firm that is also the owner of the focal game platform. Active platform owners never publish a game on a rival platform.
Project Size	Relative number of people who worked on the title compared to the average of all games released in the same year. Game releases with missing information have been given a value of 1.
Assumed Size	Dummy = 1 if game has no project size information available and given 1 as project size value.
Licensed Title	Dummy = 1 if a game is based on a license.
Sequel	Dummy = 1 if a game is a sequel in a series.
In-house	Dummy = 1 if publisher and developer belong to the same parent company.
Overall Experience Volume	Total product development experience in the past five years. Calculated for both publisher and developer.
Firm Size	Logged number of games released in a year controls for firm size. Calculated for both publisher and developer.
Firm Age	Number of years since the first game release of the firm. Calculated for both publisher and developer of the focal game.

Dependent Variable

I suggest that revenue is an appropriate performance measure for game release outcomes, and this is consistent with the product development literature's focus on product-level outcomes (Eggers, 2012). As mentioned above, this is especially true for console video games, which need to generate higher sales revenue to compensate their publishers for intense resource commitments and costly licensing deals with platform owners. I also focus only on revenues earned in the first year of a release, for two reasons. First, games spend different periods of time on the market. Second, this approach avoids the need to censor games released in the last year of data. Previous research has shown that over 80% of a video game's sales occur in its first year on the market, with a 99% pairwise correlation between sales of a game in the first and second years (Dezsö, Groshjean, and Kretschmer, 2012). Nerkar and Roberts (2004) also focus on initial sales as a good indicator of new product success, based on previous studies (Gatignon et al., 1990). I converted these revenues to 1995 dollars according to the US Consumer Price Index. Finally, I used the more normally distributed natural logarithm of revenue (lnrevenue) for my analysis, because the video games is a hit-driven industry. Therefore, the dependent variable *Revenue* is the natural logarithm of the revenues generated by a game in the first year after its release.

Independent Variables

To calculate experience variables, I used game releases by a firm in the past five years, for two reasons. First, prior studies on knowledge and innovation consider five years to be an appropriate time window (Fleming, 2001; Katila and Ahuja, 2002). Second, new console generations are released every five years, on average; thus, my approach takes into account the possibility that generational changes discount previously accumulated experience. A previous study in the same setting have also used a five year window, due to the fast changing nature of the industry (de Vaan et al., 2014). Many games are released for multiple platforms at the same time; however, I count only unique game releases in calculating experience variables. This is because "porting" a game from one console to another is a technical activity that does not accumulate relevant experience for the firm when it comes to developing a certain kind of game. *Experience Breadth:* The measure of breadth in the publisher's product release experience is based on the Herfindahl index, because it reflects the diversity of products the publisher has released in the past. It is computed as: $Breadth_i = \left[1 - \frac{\sum_j N_{ij}{}^2}{\sum_j (N_{ij})^2}\right]$, where Nij is the proportion of games released by publisher i in the past five years in genre j; that is, the number of games that the firm has in a particular genre divided by the total number of games released by the publisher in the past five years. NPD super-genres are used for this calculation. This variable ranges between 0 and 1, where 1 represents maximum diversity.

Experience Depth: This is the total volume of experience the publisher has accumulated in the past five years within the genre of the focal new game release, logged to deal with overdispersion. NPD genres are used for this calculation.

Era of Ferment: This is the period that starts with the first console release of the new technology generation and ends a year after all consoles for that generation have been released, a process that takes three years, on average. This period is chosen to allow new games to be released for all consoles in a new generation, since it takes around a year for all launch titles to appear. This measure captures the time period in which previous generation consoles are still generating most hardware sales, as occurs in the early period of the technology life cycle for the new generation. I test an alternative variable of using only a focal new platform as a robustness check.

Mature Phase and *Maturity:* First, I consider the mature phase to be the post-shakeout[11] period of the industry, as per Agarwal et al. (2002) and consistent with traditional industry evolution studies which separate growth and mature phases. Figure 3 shows that the industry maturity phase occurs from 2003 onwards.

Second, in order to test Hypothesis 2b, I created a continuous variable of maturity that tests how the impact of breadth of experience has changed through the pre-maturity, maturity, and late maturity ("de-maturity") phases of the industry, using logged average number of people working to produce a game at the industry level. As can be seen in Figure 5, the average number of people has been increasing over time. Tschang (2007) suggests that the increasing complexity of games and the concomitant labor required to build them has resulted in increasing "rationalization" of the industry, which favors classic industry evolution dynamics such as focus on process and incremental innovations.[12] Therefore, I used (logged) industry average

[11] Klepper and Miller (1995) define a shakeout as a process whereby the number of producers declines after a peak by at least 30% and does not subsequently rise to within 90% of the peak. Agarwal et al. (2002) alternatively consider a shakeout to be the "transformation of entry barriers" where gross number of entries fall down from the peak, and do not late rise to original peak levels. I follow Agarwal et al.'s (2002) approach.

[12] This is also in line with Klepper's observation that increasing product R&D expenditures to compete (Klepper, 1997, p.151), instead of increasing process R&D (Klepper, 1996), would also cause the same entry, exit, and competitive dynamics to mature the industry.

project size in the release year to measure the extent of industry maturation. I also adopt an alternative approach of looking at the effect of breadth of experience by each year of the industry.

Control Variables

Following Eggers (2012), the current study treats the overall *Product Development Experience of the Publisher* (as well as *Developer*) as a control. Again, experience in the past five years is considered to account for experience decay and it is logged to deal with overdispersion.

A set of controls relate to the title level, the most important of which is the project size itself, which reflects the budget of a game development project. The *Project Size* variable has been calculated by using credits information on MobyGames, which is the ratio of the number of people who worked on the title compared to all other titles in the same year. Since credits information is not universally available, those games which lacked this information were assigned the ratio of 1, yet they have been coded in a *Assumed Size* dummy variable in order to control for the bias introduced by this. Another important control is if a title is produced by a vertically integrated company; that is, both the publisher and developer are owned by the same parent company. Tschang (2007) notes that game development projects differ in terms of incentive and transaction cost issues if the developer is owned by the publisher. This factor is controlled with the *In-house* variable. Games could be also based on on a movie or franchise license (such as Star Wars, NFL, or FIFA). The *Licensed Title* variable controls for this. A game could be also a sequel, which is produced upon the success of previous games in the series. This is controlled with the *Sequel* variable.

At the publisher and developer level, there are three controls. Most important is the *Publisher-level Fixed Effects* for all estimations, and *Developer-level Fixed Effects* for the robustness checks. Second, firm size must also be controlled. As pointed out by previous research (de Vaan, 2014), it is virtually impossible to collect revenue and employee data for the many small development firms. It has also been noted that the number of games released in a year is 0.95 correlated with firm revenue for a subset (p. 1675). Therefore *Logged Number of Games* released in a year controls for firm size. The final firm-level controls are *Publisher Age, Developer Age, and Console Owner*. The latter controls for the fact that some video games are produced by console owners, which arguably have different incentives for, and information on, leveraging new generation consoles.

As a last set of control variables, dummies have been created to control for console generation year (and its squared term) specific, genre-specific, and platform-specific effects on game revenues. Each generation of consoles has its own dynamics that unfold over time, where publishers showcase more "original" products to leverage new technologies with the latest generation consoles. Later on, these firms exploit the existing base of consoles with more incremental products. To control for these cyclical effects, *Console Generation Year* fixed effects are added. Rietveld (2015) found that these cyclical effects have a non-linear relationship, showing inverted U-shaped relationships according to the variables of interest (e.g., game sales show an inverted U-shaped relationship with number of years in a console generation). Therefore, I also control for *Console Generation Year, Squared*. At the genre level, some genres could be more popular than others overall (action vs. strategy); therefore, I add *Genre Fixed Effects* for all NPD genres. Again, some platforms may be more popular than others, influencing the revenues of a title in a platform (though note that popularity may not necessarily lead to higher revenues; see Cennamo and Santalo, 2013). This is controlled with *Platform Fixed Effects*.[13]

Analysis Procedures and Descriptive Statistics

The models used are OLS with robust standard errors clustered at the publisher level and with fixed publisher, console-generation year (and its squared term), platform and genre effects, with one observation for each new title on a platform released. Firm fixed effects are important for two reasons. First, they control for unobserved heterogeneity between organizations. Second, they allow for evaluations of how within-firm changes in experience variables are affected by evolutionary changes in determining outcomes (Eggers, 2012). All independent and control variables are lagged for one year in analysis.[14]

Table 2 presents the summary statistics and correlations. The results show that none of the key variables, especially breadth and depth of experience are highly correlated, all being below or equal to .26. This lends further support to the idea that breadth and depth of experience

[13] I have also tested my hypotheses with additional control variables in which I dropped in my final estimations. These include exclusivity at the title level, industry sales at the industry level, and year fixed effects. None of these variables changed the results of the hypothesized relationships in terms of significance or direction. Both industry level sales and year fixed effects were highly collinear, but I show at the robustness check section that year effects do not affect results.

[14] Other possible alternative explanations and endogeneity problems of estimations will be tackled in the next section.

TABLE 2

Means, Standard Deviations, Minimums, Maximums, and Correlations

	Variables	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Game Revenue[b]	14.59	1.56	4.2	19.3																	
2	Console Owner	0.13	0.34	0	1	.17																
3	Project Size	1.09	0.69	0	11.1	.28	.02															
4	Assumed Size Dummy	0.18	0.38	0	1	-.12	-.04	-.06														
5	Licensed Title	0.44	0.5	0	1	.15	-.13	.08	.09													
6	Sequel Title	0.41	0.49	0	1	.26	.02	.10	.02	.00												
7	In-house	0.44	0.5	0	1	.24	.00	.19	.04	.06	.22											
8	Publisher Age	14.22	6.14	1	27	.32	.07	.16	-.04	.12	.24	.27										
9	Developer Age	9.8	7.19	0	27	.23	-.03	.12	.01	.02	.24	.63	.47									
10	Pub. Total Experience	93.1	1.07	0	320	.26	.35	.27	-.04	.18	.19	.21	.44	.17								
11	Dev. Total Experience	29.3	1.52	0	135	.26	.04	.21	.05	.13	.26	.66	.39	.60	.54							
12	Publisher Size[b]	3.26	0.88	0.7	4.7	.27	.10	.26	-.06	.24	.16	.22	.39	.13	.78	.34						
13	Developer Size[b]	2.1	1.07	0.7	4.5	.24	-.05	.22	.01	.18	.23	.74	.34	.61	.39	.85	.48					
14	Era of Ferment	0.23	0.42	0	1	-.03	.09	.03	.01	-.09	-.03	.08	-.09	.00	-.02	.05	.03	.05				
15	Mature Phase	0.42	0.49	0	1	.07	-.14	.01	.02	.08	.10	.07	.38	.27	.12	.10	.05	.14	-.24			
16	Experience Depth[ac]	1.46	0.98	0	4.3	.22	.13	.18	-.09	.10	.24	.21	.33	.18	.56	.29	.45	.29	-.04	.10		
17	Experience Breadth[a]	0.8	0.12	0	1	.19	.16	.07	-.06	.07	.08	.06	.38	.11	.63	.12	.38	.09	-.05	.07	.25	
18	Industry-year average project size[ac]	4.63	0.53	3.7	5.4	.15	-.18	.00	.02	.11	.13	.07	.49	.32	.14	.10	.07	.15	-.26	.84	.12	.12

a: Variable is mean-centered for regressions, but descriptives are reported on uncentered variable.
b: Logarithm.
c: Variable descriptives (mean, SD, min, max) reported as normal, but correlations calculated with logged variable.
N = 4,852.

are different dimensions of experience. However, several control variables are highly correlated with experience variables, which highlights the need to control for them to seperate their effect on product development outcomes (such as overall experience). Average variance inflation factors range between 3.84 to 6.26 according to the models, indicating that there are no serious problems of multicollinearity.[15]

RESULTS

The results are reported in Table 3 and subsequent tables. I describe the results for the control variables below, but have suppressed them from the tables so as not to obscure the key relationships. In the full model (Model 4), nine out of fourteen control variables are significant. *Licensed Titles* and *Sequels* to a previous titles increase game revenues, as expected. Similarly, the *Project Size* variable is significant and positive. It is clear that games for which there is no credits data are the less succesful or smaller titles, and this bias is captured by the dummy variable which is significant and negative. The coefficient on *Console Owner* is positive and significant, suggesting that console owners release more successful games—consistent with findings in the platform markets literature (Lee, 2013). Also, games that are developed *In-house*, by developers and publishers who belong to the same parent company are more successful, as suggested by the positive and significant coefficient. Only *Developer Age* is positively significant, while both *Publisher* and *Developer Overall Experience* affect development success positively (althought for publisher it is marginally significant). *Publisher Age, Publisher Size* and *Developer Size, Years in the Console Generation* and its *Squared* terms are not related to product success.

Model 1 includes experience depth and breadth variables. None are significant, which reflects ealier discussions on the importance of considering context, and the mixed results from previous studies. Hypotheses 1a and 1b focus on the contingent effects of experience breadth and depth transitioning to a new technology life cycle (i.e., era of ferment) and predict that the impact of deeper experience on product success becomes less positive (more negative) after a new technological cycle (Hypothesis 1a), while the impact of broader experience becomes more positive (Hypothesis 1b).

[15] I follow recent advice against mean centering as a solution for multicollinearity (Echambadi and Hess 2007). I tested all models after mean centering and found that the VIF values drop, but the results do not change at all.

TABLE 3

New product performance with moderating effects of technological change, and industry maturation for breadth and depth of experience. Publisher Fixed-effect OLS Regression Model, DV = (Logarithm) Revenue

VARIABLES	Model 1	Model 2	Model 3	Model 4
Controls	YES	YES	YES	YES
INDEPENDENT VARIABLES				
Mature Phase	-0.047	-0.051	-0.999*	-1.347**
	(0.078)	(0.078)	(0.443)	(0.425)
Era of Ferment	-0.021	-1.082**	-0.035	-1.263**
	(0.085)	(0.346)	(0.085)	(0.377)
Experience Depth	0.057	0.089*	-0.009	0.028
	(0.035)	(0.037)	(0.049)	(0.051)
Experience Breadth	-0.290	-0.990^	-0.274	-1.145^
	(0.505)	(0.533)	(0.571)	(0.605)
INTERACTIONS				
Era of Ferment x Experience Depth		-0.143**		-0.118*
(H1a: -)		(0.050)		(0.049)
Era of Ferment x Experience Breadth		1.587***		1.752***
(H1b: +)		(0.416)		(0.449)
Mature Phase x Experience Depth			0.142**	0.120*
(H2a: +)			(0.051)	(0.050)
Mature Phase x Experience Breadth			0.884	1.350*
			(0.552)	(0.530)
Constant	15.307***	15.875***	15.489***	16.267***
	(1.998)	(1.861)	(2.035)	(1.889)
Observations	4,852	4,852	4,852	4,852
R-squared	0.320	0.324	0.323	0.327
Number of Publishers	139	139	139	139
Publisher FE	YES	YES	YES	YES
Platform FE	YES	YES	YES	YES
Generation-year FE	YES	YES	YES	YES
Genre FE	YES	YES	YES	YES

(Fixed effects model with Publishers as focus; robust standard errors clustered by publisher; outcome is natural logarithm of cumulative first 12 month sales of title released for a platform; independent variables are one-year lagged; random effects are inconsistent according to both Hausman and heteroskedasticity robust Hansen-Sargan tests ($p < 0.001$)).
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10.

FIGURE 4
Interaction of Experience Depth and Era of Ferment

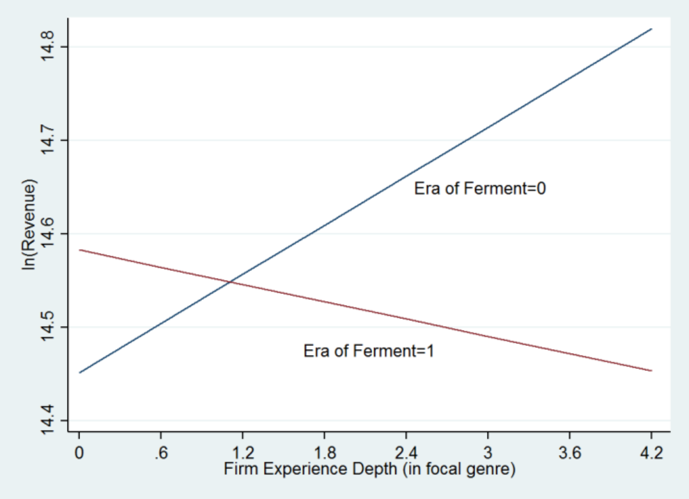


FIGURE 5
Interaction of Experience Breadth and Era of Ferment

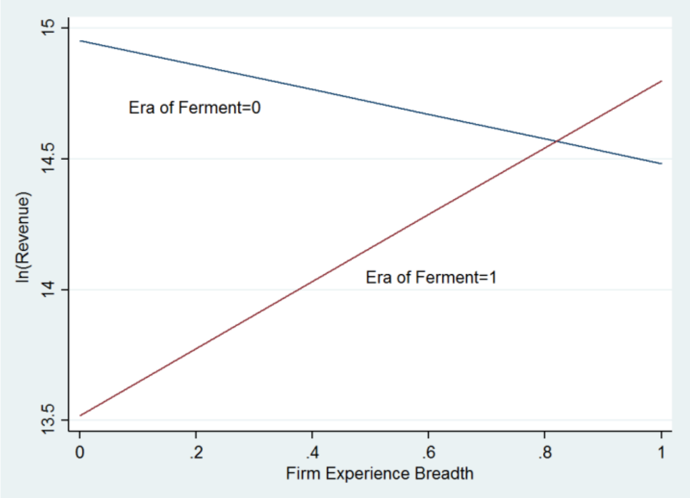
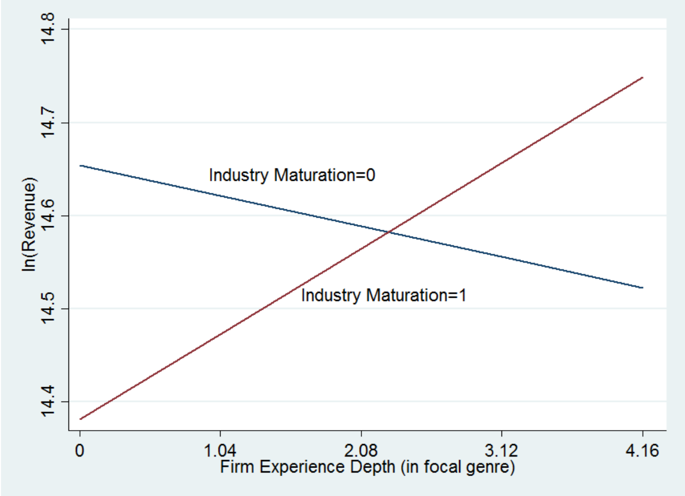


FIGURE 6
Interaction of Experience Depth and Industry Maturation



In Model 2 and Model 4, interactions of *Era of Ferment x Experience Depth* and *Era of Ferment x Experience Breadth* are significant and in the expected direction. Hence, the deeper the experience, the less positive and the broader the experience, the more positive the impacts of these experiences on product development success in an era of ferment. The form of the interaction with depth of experience, as seen in Figure 4[16], shows that products developed with deeper experience achieve higher success only in old technology life cycle (those console generations that were already three or more years old according to console generation), while showing a downward slope during times following a new technology life cycle (though not significant). Conversely, Figure 5 shows that products developed with broader experience achieve higher success only in a new technology life cycle, while showing a downward slope in an old technology life cycle. Thus Hypotheses 1a and 1b are supported: the impact of the depth and breadth of experience on product development success is contingent on technology life cycle, and in the theorized directions.

Hypothesis 2a deals with the relationship between experience depth and industry maturation (industry life cycle). The interaction term *Mature Phase x Experience Depth* is significant and postive in Model 3 and Model 4, supporting the hypothesis. Marginal effects analysis shows that *Experience Depth* has a positive significant effect ($p < 0.01$) on game revenue, only in the mature phase of the industry. Figure 6 visualizes this interaction, which shows a strong upward slope for depth of experience during the mature phase of an industry and a weaker downward slope during the growth phase of the industry.

Finally, Hypothesis 2b predicted that breadth of experience will have a contingent effect on product success according to different stages of the industry life cycle: growth, maturity, and "de-maturation" (late maturity). The earlier *Mature Phase* variable is binary, consistent with traditional industry evolution studies (Agarwal et al., 2002); hence, I use a continuous *Maturity* variable to test Hypothesis 2b. As explained earlier, the average number of people working to produce a game at the industry level is a good reflection of the maturity of the industry. In Table 4, I test Hypothesis 2b (and also previous Hypotheses, to confirm previous findings) with this variable. Models 2, 3, and 4 confirm previous findings on Hypotheses 1a, 1b, and 2a. Looking at Model 4, we can see that *Maturity x Experience Breadth* interaction is significant and

[16] All Figures drawn are within the range of the data. Due to availability of multiple interactions in the same model, unless stated, all Figures are drawn using the "as balanced" option of STATA 14, which "specifies that factor covariates be evaluated as though there were an equal number of observations in each level".

negative, while *Maturity*, *Squared x Experience Breadth* interaction is significant and positive, supporting Hypothesis 2b: the impact of broader experience first becomes less positive (more negative) as the industry passes through the growth stage to maturity stage, but then becomes more positive as the industry enters the later "de-maturation" stage.[17] Model 5 presents the fully saturated model to show that the possible interaction between depth of experience and squared maturity term is not significant. These findings support Hypothesis 2b, and confirm earlier findings on Hypotheses 1a,1b, and 2a. Figure 7[18] shows the interaction of breadth of experience at three stages of the industry life cycle (at the point of Era of Ferment=0). We can see not only that the broader the experience, the less positive (more negative) its effect on product development success in the mature period, but that it also has an overall negative marginal effect ($p < 0.05$) on product revenue. Figure 8 shows that (at the point of Era of Ferment=1) the broader the experience, the more positive is the effect on product development success in the growth and de-maturation period of the industry; and again having an overall positive marginal effect in both periods ($p < 0.05$) on product revenue. In summary, breadth of experience increases revenues in the growth stage of the industry, decreases revenues in the maturity stage, and increases revenues in the de-maturity stage.

These results can be corroborated with some qualitative evidence on video game publishers. Ubisoft's CEO Yves Guillemot makes the following comment about technology life cycles. His quote reveals why publishers benefit from their deeper experiences well into the technology life cycle, but not at all early on:

> "It's a lot less risky for us to create new IPs and new products when we're in the beginning of a new generation... Our customers are very open to new things. Our customers are reopening their minds -- and they are really going after what's best. ... At the end of a console generation, they want new stuff, but they don't buy new stuff as much".[19]

There are two prominent examples of publishers which inititally benefited from their deeper experiences, but were eventually harmed (or even failed) when broader experience become important later on in the industry life cycle. First, EA (Electronic Arts) was the biggest

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[17] A year-by-year spline function estimation will also confirm this finding in the robustness section.
[18] Since there are multiple significant interactions with a shared variable (Breadth of Experience), interactions show different effects according to the value that second interacting contingency takes (New Technology Generation Transition=0 or 1). Therefore a complete interpretation requires looking both of them.
[19] http://www.gamasutra.com/view/news/174498/Ubisofts_Guillemot_New_consoles_are_overdue.php, accessed 29 October 2015.

TABLE 4. Testing Hypothesis 2b with Continuous Measure of Industry Maturity (Log Average of Industry Level Project Size in a Year). Publisher Fixed-effect OLS Regression Model, DV = (Logarithm) Revenue

VARIABLES	Model 1	Model 2	Model 3	Model 4	Model 5
Controls	YES	YES	YES	YES	YES
INDEPENDENT VARIABLES					
Maturity	-0.802	-0.412	15.678^	17.079*	17.195*
	(1.509)	(1.536)	(8.746)	(8.224)	(8.260)
Maturity, Squared	0.086	0.052	-1.767^	-1.936*	-1.951*
	(0.132)	(0.135)	(0.949)	(0.895)	(0.899)
Era of Ferment	-0.059	-1.108**	-0.076	-1.201***	-1.201***
	(0.102)	(0.353)	(0.102)	(0.330)	(0.330)
Experience Depth	0.058	0.089*	-0.620*	-0.506^	0.322
	(0.035)	(0.037)	(0.293)	(0.291)	(2.214)
Experience Breadth	-0.272	-0.975^	46.238^	47.767*	46.528*
	(0.505)	(0.535)	(23.958)	(22.167)	(22.576)
INTERACTIONS					
Era of Ferment x Experience Depth		-0.140**		-0.116*	-0.121*
(H1a: -)		(0.050)		(0.049)	(0.054)
Era of Ferment x Experience Breadth		1.588***		1.638***	1.645***
(H1b: +)		(0.414)		(0.384)	(0.384)
Maturity x Experience Depth			0.145*	0.126*	-0.237
(H2a: +)			(0.058)	(0.057)	(0.928)
Maturity, Squared x Experience Depth					0.039
					(0.097)
Maturity x Experience Breadth			-20.740^	-22.034*	-21.502*
(H2b: -)			(10.656)	(9.938)	(10.104)
Maturity, Squared x Experience Breadth			2.280^	2.456*	2.400*
(H2b: +)			(1.157)	(1.085)	(1.101)
Constant	17.663***	17.174***	-18.321	-20.515	-20.726
	(3.976)	(3.965)	(20.007)	(18.636)	(18.694)
Observations	4,852	4,852	4,852	4,852	4,852
R-squared	0.320	0.324	0.324	0.327	0.327
Number of Publishers	139	139	139	139	139
Publisher FE	YES	YES	YES	YES	YES
Platform FE	YES	YES	YES	YES	YES
Generation-year FE	YES	YES	YES	YES	YES
Genre FE	YES	YES	YES	YES	YES

(Fixed effects model with Publishers as focus; robust standard errors clustered by publisher; outcome is natural logarithm of cumulative first 12 month sales of title released for a platform; independent variables are one-year lagged; random effects are inconsistent according to both Hausman and heteroskedasticity robust Hansen-Sargan tests ($p < 0.001$)).
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10.

FIGURE 7
Interaction of Experience Breadth and Industry Maturation (at Era of Ferment=0)

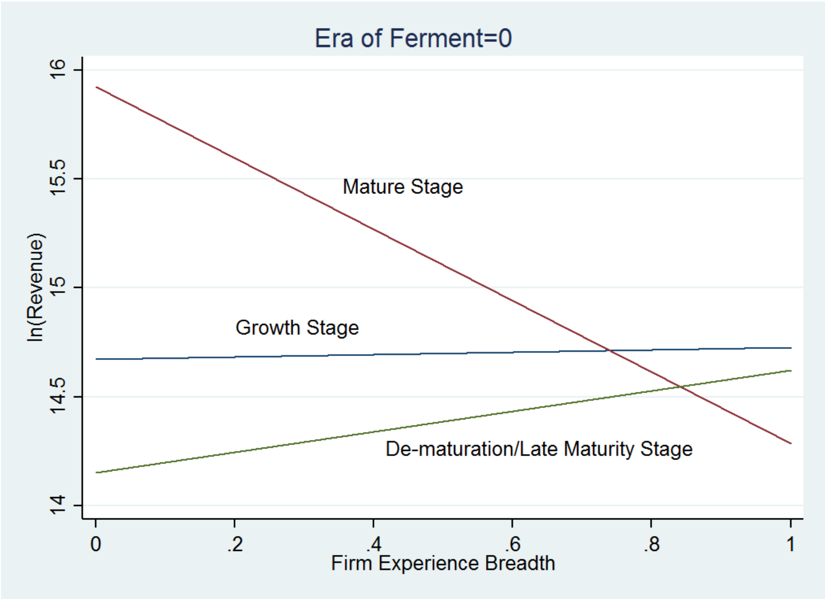
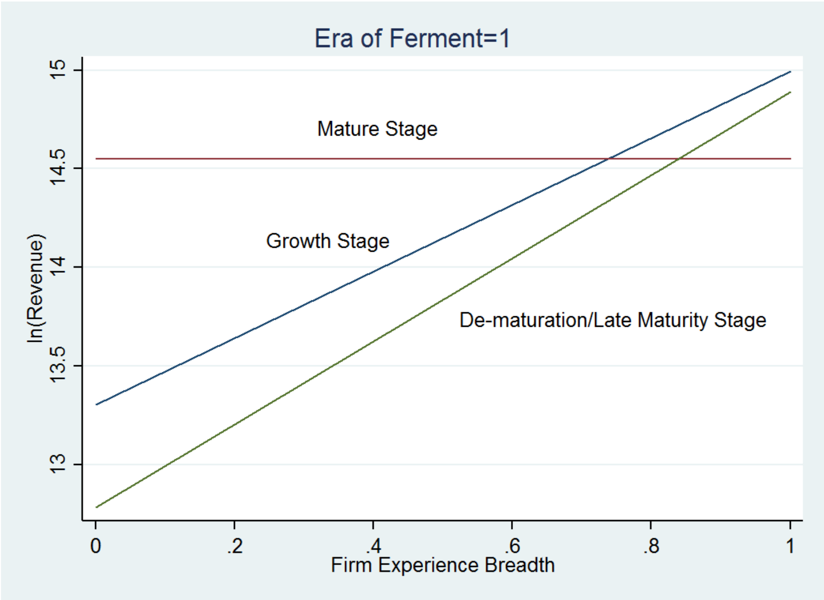


FIGURE 8
Interaction of Experience Breadth and Industry Maturation (at Era of Ferment=1)



publisher in the period of observation of my study. It began generating losses around 2006, as it entered the de-maturation period. For years prior, EA had focused on the genres in which it had very deep experience, and it was surprised by its poor financial performance:

> "EA became the games industry's 800-pound gorilla...monopolise entire genres for years on end. It created franchises which were annually refreshed, milking the cash cow anew with each iteration... After years when it seemed content to sit back and churn out annual updates and movie licences, EA has been brought up short by a stagnation of its income - at a time when its development expenses have skyrocketed..."[20]

EA realized that market was changing and it reinvented itself as a broader company offering different games in genres, and so on:

> "Riccitiello's sure hand on the tiller is guiding the firm back into the kind of waters that Trip Hawkins originally envisioned back in the 1980s, and words like risk, innovation and originality are no longer dirty." [21]

The second example is that of THQ, which was one of the biggest publishers in the industry just a few years before filing for bankruptcy. THQ relied on many licensed children's titles, and began to experience massive losses towards the end of the 2000s. It changed its product development strategy and broadened its genres, focusing on bigger titles, which were the industry mandate. But the firm had no previous experience in these genres:

> "The company that had generated millions from games based on Finding Nemo and WWE, had struggled to transition into a world where kids games and licensed titles were no-longer safe bets... In an industry that's enduring a painful transition away from the triple-A, boxed game model, mid-tier publishers are the ones that will ultimately get squeezed out. THQ is just the first big victim... It is also quite important with projects of this size that THQ was dealing with, that these projects are being thought through from start to finish early on, and you don't run into

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[20] http://www.eurogamer.net/articles/electronic-arts-back-in-the-game-article, accessed 29 October 2015.
[21] ibid.

problems of discontinuing development or changing a game concept in the middle of the development."[22]

Robustness, Alternative Explanations, and Economic Significance

As discussed throughout this paper, multiple robustness checks were performed in order to ensure the validity of results. Other tests were conducted to discard possible alternative explanations and to address non-exogenous decisions made by firms. These tests are shown in Tables 5, 6, and 7. Model 0 in Tables 5 and 6 repeats the full model from Table 3.

The first four models use alternative experience variables to address two issues: (i) the fact that concordance between MobyGames and NPD data at the genre level was a little above 60%, and (ii) that results may be sensitive to different aggregations or definitions of depth and breadth of experience. Model 1 and Model 2 test an alternative measurement of depth of experience, based on the 102 game characteristics provided by MobyGames. Experience depth is measured by how much experience the firm has accumulated on average with each characteristic element existing in the focal product, similar to Fleming (2001). However, this variable is highly correlated with the total experience variable (.89), which is likely to result in weaker results. Looking at these models, we can see that this alternative definition of depth is still marginally significant for the first interaction, and strongly significant for the second interaction. These results also give an early indication that the original results are not an artifact of concordance issues. Model 3 tests using an Entropy measure instead of Herfindahl measure to calculate the breadth variable—the results are the same. Model 4 uses NPD genre level to calculate the breadth variable (same level with the depth variable) in order to check whether the results were driven by aggregation level or affected by lower concordance at the genre level (vs. super-genre level, which was above 90%). All results remain the same; therefore, I am confident that these issues are not driving the results.

Additional robustness checks are as follows: Models 5, 6, and 7 test year fixed-effects (which was not included due to multicollinearity with maturation variable), and developer fixed-effects (to control any results driven by heterogeneity of game developers, in addition to controlling publisher fixed-effects). The results hold in both cases, giving additional confidence to my findings. In Table 6, Model 8 and Model 9 test alternative variables for the Era of

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[22] http://www.engadget.com/2008/11/05/thq-reveals-significant-business-realignment/, accessed 29 October 2015.

TABLE 5. Robustness Checks

VARIABLES	Model 0 Base Full Model	Model 1 Alt Depth	Model 2 Alt Depth Full Model	Model 3 Alt Breadth	Model 4 Sub-genre Breadth	Model 5 Year FE	Model 6 Develope r FE	Model 7 Develope r FE Full Model
Controls	YES	YES	YES	YES	YES	YES	YES	YES
INDEPENDENT VARIABLES								
Mature Phase	-1.347**	0.008	-1.254**	-1.042**	-1.365*	(omitted)	0.033	-2.049***
	(0.425)	(0.076)	(0.416)	(0.313)	(0.529)		(0.088)	(0.469)
Era of Ferment	-1.263**	-1.152***	-1.255***	-0.830**	-1.202**	-1.516***	-1.431**	-1.712**
	(0.377)	(0.332)	(0.365)	(0.285)	(0.396)	(0.427)	(0.522)	(0.558)
Experience Depth	0.028	0.005**	0.002	0.037	0.036	0.037	0.051	-0.012
	(0.051)	(0.002)	(0.002)	(0.051)	(0.053)	(0.053)	(0.047)	(0.064)
Experience Breadth	-1.145^	-0.885	-1.032^	-0.357*	-1.049^	-1.042^	-1.415*	-1.720*
	(0.605)	(0.543)	(0.599)	(0.171)	(0.589)	(0.621)	(0.649)	(0.683)
INTERACTIONS								
Era of Ferment x Experience Depth	-0.118*	-0.003^	-0.002	-0.126*	-0.127*	-0.135**	-0.105^	-0.079
(H1a: -)	(0.049)	(0.002)	(0.002)	(0.051)	(0.052)	(0.048)	(0.054)	(0.057)
Era of Ferment x Experience Breadth	1.752***	1.451***	1.620***	0.513***	1.519***	1.630***	1.946**	2.232**
(H1b: +)	(0.449)	(0.412)	(0.430)	(0.141)	(0.438)	(0.472)	(0.634)	(0.682)
Mature Phase x Experience Depth	0.120*		0.006**	0.106*	0.110*	0.110*		0.125*
(H2a: +)	(0.050)		(0.002)	(0.049)	(0.053)	(0.050)		(0.051)
Mature Phase x Experience Breadth	1.350*		1.238*	0.421**	1.257*	1.256*		2.277***
	(0.530)		(0.537)	(0.158)	(0.606)	(0.533)		(0.582)
Constant	16.267***	16.707***	16.206***	15.945***	16.215***	11.762***	14.026***	14.643***
	(1.889)	(0.654)	(1.822)	(1.864)	(1.878)	(2.484)	(2.478)	(2.482)
Observations	4,852	4,852	4,852	4,852	4,852	4,852	4,852	4,852
R-squared (within)	0.327	0.322	0.326	0.326	0.326	0.333	0.507	0.510
Number of Publishers	139	139	139	139	139	139	139	139
Publisher, Platform, Generation-year, and Genre FE	YES	YES	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO	YES	NO	NO
Developer FE	NO	NO	NO	NO	NO	NO	YES	YES

(Fixed effects model with Publishers as focus; robust standard errors clustered by publisher; outcome is natural logarithm of cumulative first 12 month sales of title released for a platform; independent variables are one-year lagged; random effects are inconsistent according to both Hausman and heteroskedasticity robust Hansen-Sargan tests (p < 0.001)).
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10.

TABLE 6. Robustness Checks (Continued)

VARIABLES	Model 0 Base	Model 8 New Focal Console	Model 9 Years in the generation (inverse sign for H1a and H1b)	Model 10 Industry level tech. change	Model 11 Only 3rd Party Games (No Console Owners)
Controls	YES	YES	YES	YES	YES
INDEPENDENT VARIABLES					
Mature Phase	-1.347**	-1.198*	-1.070*	-1.244**	-1.108*
(Model 4=Continuous Maturity Variable)	(0.425)	(0.472)	(0.473)	(0.434)	(0.455)
Era of Ferment	-1.263**	-0.632^	0.630^	-0.564*	-1.170**
(Model 2=Continuous Transition Variable)	(0.377)	(0.370)	(0.346)	(0.266)	(0.385)
Experience Depth	0.028	0.044	-0.162**	-0.001	0.047
	(0.051)	(0.053)	(0.060)	(0.049)	(0.061)
Experience Breadth	-1.145^	-0.734	2.101^	-0.633	-1.054^
	(0.605)	(0.674)	(1.081)	(0.540)	(0.617)
INTERACTIONS					
Era of Ferment x Experience Depth	-0.118*	-0.138**	0.028**	-0.047*	-0.108^
(H1a: -, + for Model 9)	(0.049)	(0.043)	(0.009)	(0.023)	(0.062)
Era of Ferment x Experience Breadth	1.752***	1.071*	-0.745*	0.636^	1.577***
(H1b: +, - for Model 9)	(0.449)	(0.432)	(0.357)	(0.341)	(0.452)
Mature Phase x Experience Depth	0.120*	0.102*	0.123*	0.116*	0.104^
(H2a: +)	(0.050)	(0.051)	(0.052)	(0.051)	(0.056)
Mature Phase x Experience Breadth	1.350*	1.202*	1.008^	1.190*	1.065^
	(0.530)	(0.591)	(0.580)	(0.548)	(0.586)
Constant	16.267***	15.943***	14.015***	17.584***	16.248***
	(1.889)	(1.979)	(2.225)	(1.925)	(2.026)
Observations	4,852	4,852	4,852	4,852	4,225
R-squared (within)	0.327	0.325	0.326	0.328	0.327
Number of Publishers	139	139	139	139	137
Publisher, Platform, Generation-year, and Genre FE	YES	YES	YES	YES	YES

(Fixed effects model with Publishers as focus; robust standard errors clustered by publisher; outcome is natural logarithm of cumulative first 12 month sales of title released for a platform; independent variables are one-year lagged; random effects are inconsistent according to both Hausman and heteroskedasticity robust Hansen-Sargan tests ($p < 0.001$)).
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10.

Ferment: *New Console* and *Years in the Generation*, respectively. If my variable is indeed measuring technological discontinuity through newer generations of hardware, I would expect it to also be significant looking at individual new consoles. The results confirm this expectation. Similarly, Model 9 tests a continuous measure of the age of the technology life cycle, and it is expected to interact negatively early on with depth of experience and positively with breadth of experience. This is also confirmed, giving additional confidence to my results for H1a and H1b.

Tests for alternative explanations were also conducted. The first considers whether accumulation of experience is endogeneous to firm choices, leading them to self-select: (i) their choice to join a technology life cycle, and (ii) their accumulation of previous experience (breadth, in that case) in preparation for new technology life cycles. Both of these cases would make experience endogeneous, and bias results. To account for this, I created another variable measuring the level of technical change at the industry level, following the approach used by de Vaan (2014) in the same industry setting. This variable "*console turbulence*" measures the extent to which video game firms can explore the boundaries of new technologies introduced by consoles in the market. This measure is simply constructed by total number of consoles available in the market in a given year, weighted by each console's remaining life on the market. Therefore, more consoles available in the market, as well as newer consoles, produce a higher measure. Note that this measure is calculated for the whole industry, and therefore is impervious to the self-selection of a technology life cycle argument (as it has the same value for games released for both the older and new technology life cycle in a given year). Naturally, this variable should interact more weakly with our variables, because it reflects the whole industry. Table 6, Model 10 shows that both depth and breadth of experience interact significantly using this alternative variable for era of ferment.

Nevertheless, the possibility remains that firms deliberately accumulate experiences to pre-dispose themselves to new technology cycles. I address this issue both conceptually and methodologically. From a conceptual standpoint, it is not plausible to expect that publishers will increase their breadth of experience in anticipation of a new technology cycle. Research has already shown that publishers tend to heavily exploit the large installed base of older technology cycle as "software providers continue to exploit the installed base of hardware users after hardware demand has slowed" (Clements and Ohashi, 2005; p. 515). Publishers which increase their breadth before a new cycle starts should publish games in market segments where they have little or no experience. In so doing, they forfeit the profits they could have reaped by

TABLE 7
Testing Hypothesis 2b with Year-by-Year Splines (Reference Year=2002).

VARIABLES	Model 1	Model 2	Model 3	Model 4
Controls	YES	YES	YES	YES
INDEPENDENT VARIABLES				
Year Dummies (Reference = 2002)	YES	YES	YES	YES
Era of Ferment	-0.404^	-1.369***	-0.444*	-0.904
	(0.215)	(0.393)	(0.206)	(0.656)
Experience Depth	0.058	0.093*	0.043	0.043
	(0.035)	(0.038)	(0.064)	(0.064)
Experience Breadth	-0.261	-0.894	-2.508*	-2.531*
	(0.497)	(0.545)	(0.987)	(0.988)
INTERACTIONS				
Era of Ferment x Experience Depth		-0.157**		-0.187**
		(0.049)		(0.071)
Era of Ferment x Experience Breadth		1.473***		0.880
		(0.435)		(0.806)
Year Dummies x Experience Depth			YES	YES
Year 1995 x Experience Breadth			2.525*	2.411^
			(1.245)	(1.236)
Year 1996 x Experience Breadth			3.314**	2.621*
			(1.077)	(1.270)
Year 1997 x Experience Breadth			-0.146	-0.088
			(1.134)	(1.136)
Year 1998 x Experience Breadth			0.112	0.159
			(1.183)	(1.186)
Year 1999 x Experience Breadth			1.267	1.174
			(0.952)	(0.951)
Year 2000 x Experience Breadth			1.866	1.473
			(1.728)	(1.887)
Year 2001 x Experience Breadth			1.746	1.119
			(1.063)	(1.272)
Year 2003 x Experience Breadth			2.844**	2.863**
			(0.993)	(0.996)
Year 2004 x Experience Breadth			2.229^	2.214^
			(1.272)	(1.275)
Year 2005 x Experience Breadth			1.299	1.271
			(1.131)	(1.130)
Year 2006 x Experience Breadth			2.846*	2.795*
			(1.113)	(1.116)
Year 2007 x Experience Breadth			4.214**	3.738**
			(1.439)	(1.427)
Constant	17.995***	18.406***	29.624***	29.255***
	(2.760)	(2.721)	(4.260)	(4.336)
Observations	4,852	4,852	4,852	4,852
R-squared	0.327	0.331	0.337	0.339
Number of Publishers	139	139	139	139
Publisher, Platform, Generation-year, and Genre FE	YES	YES	YES	YES

(Fixed effects model with Publishers as focus; robust standard errors clustered by publisher; outcome is natural logarithm of cumulative first 12 month sales of title released for a platform; independent variables are one-year lagged; random effects are inconsistent according to both Hausman and heteroskedasticity robust Hansen-Sargan tests ($p < 0.001$)). *** $p<0.001$, ** $p<0.01$, * $p<0.05$, ^ $p<0.10$.

utilizing their deep experiences in their active genres by publishing games in the old technology lifecycle.

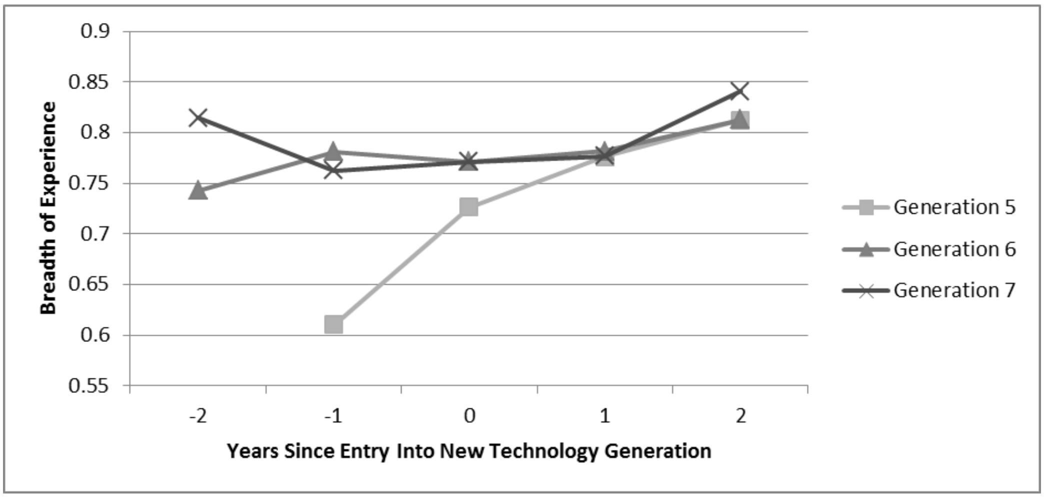
Empirically, Figure 9 shows the mean level of experience breadth for those publishers that entered a new technology life cycle (console generations 5, 6, and 7) and also their breadth of experience up to two years before entry as well as up to two years after entry.[23] This figure shows that there is no systematic increase in the breadth of experience before entry—only Generation 5 shows a significant increase in breadth before entry. However, this is occuring in the earlier years of the industry (1995–1996), a period in which many publishers increased their breadth of experience – as proven by the same line increasing consistently after entry to the new generation. Finally, to assure that firms entering the new Generation 5 console cycle were not driving the results, I ran the full model in Table 3, Model 4 with observations for the years 1998–2001. The results remain positive and significant for the *Era of Ferment x Experience Breadth* interaction ($p < 0.01$).

Another alternative explanation concerns console owners, which possess more insider information about their own new technologies and may be in a position to benefit from them. If these owners are also the publishers (i.e., first-party developers) which are high in experience breadth (or low in experience depth), they may be driving the results regarding Hypothesis 1a and 1b. Table 6, Model 11 tests the full model in Table 3 Model 4, excluding games published by console owners[24]. As can be seen, the results still hold for H1a and H1b (although somewhat weaker for H1a).

A last analysis shows the robustness of the Hypothesis H2b findings, and uses year-by-year splines of the effect of breadth of experiences evolving over time. As previously argued, I expect a positive interaction with breadth of experience effect in the earliest years and latest years of observations, and a negative effect during the in-between years. Table 7 shows the results for this effect, using 2002 as the reference year. It is easy to see there is a postive significant effect in the earliest years of 1995 and 1996 interacting with breadth of experience, and again a positive significant effect in the latest years. In-between years are non-significant, since year of reference represents the lowest effect—making the reference year 2007 makes in-between years negative and significant.

[23] Firms that were at least three years old at the time of the new technology generation entry were said to have the same comparable sample across t-2 to t+2 of new technology generation entry.
[24] This does not exclude all console owner firms. Specifically, 3DO, Sony, and Sega worked as 3rd party publishers, either when they exited the hardware business (3DO and Sega) or before they entered it (Sony).

FIGURE 9
Pre-entry and post-entry experience breadth of publishers entering new console generations



Let me also provide some information about the economic significance of my results, following the order of hypotheses. According to Table 3, Model 4, a 10% increase in experience depth increases mean revenues by 8% (~$600,000), which is a significant amount given that the observations span from 1995 to 2007 (in 1995, this difference itself could have covered all game development and publishing costs of a small sized publisher in a year!) At eras of ferment, no such benefits are sought from deeper experience. On the other hand, a 10% increase in experience breadth increases mean revenues by almost 13% (~$1,000,000), which is a very important boost for sales of one game, yet only observed at eras of ferment. Turning to industry maturation, a 10% increase in experience depth increases mean revenues by 9% (~$675,000), whereas a 10% increase in experience breadth (Table 4, Model 4) increases revenues by 8.8% (~$660,000$) in 1995, reduces it by 8.2% (~$615,000) around 2002, and again increases it by 12% in 2007 (~$900,000). These are all important amounts of money, considering they reflect revenues of each title-platform release. For a publisher, the sum of these differences in a given year could easily represent several million dollars to the firm's bottom line. This is critical in a business which depends on continuous funding and on collecting revenues from previous investments to sustain growth.

DISCUSSION AND CONCLUSION

Traditionally, scholars have studied the link between experience and product development performance through a static lens, yet that has returned inconsistent and weak results. In contrast, firms develop their products in industries characterized by constantly changing market conditions. My premise is that one must look at the industry context and temporal changes in the environment to discern how depth and breadth of experience impact product development performance. I therefore developed and tested a model that considered two major evolutionary changes that could explain the contingencies brought about by changes in the market. Further, I deviated from traditional industry evolution research by considering the often observed, but rarely discussed, “de-maturation” period in my conceptual framework and analysis. The following discussion highlights my key findings that have critical implications for future studies of the link between experience and product development performance. My work also offers important insights for the industry evolution literature. Finally, the results have implications for broader studies that consider the link between experience and outcomes in other firm activities, such as acquisitions, alliances and restructurings.

First, my central finding that both depth and breadth of experience have contingent effects based on technology and industry life cycles has implications for studies of the firm-level drivers of product development performance, especially those that look at experience as a critical factor (Danneels, 2002; Nerkar and Roberts, 2004; Salvato, 2009; Eggers, 2012). In fact, my results show that depth and breadth of experience have an effect on product development performance only based on these contingencies – both are insignificant when these contingencies are not considered. Experience depth increases product development performance only in older technology life cycles and in mature (including de-maturation) industry life cycle. It has no effect otherwise. On the other hand, expereince breadth increases success early on in a technology life cycle, as well as in de-maturation. Previous large-scale studies on the link betwen experience and product development outcomes have assumed that an industry’s market conditions remain relatively stable across time. This is a questionable assumption, given my findings. In the industry I studied, both the technologies and inputs invested in products changed in orders of magnitude. There were also critical changes in the industry’s demand structure, which became mainstream news after the release of Nintendo Wii (and, although not in my observation period, again with the rising importance of mobile games after 2010). In turn, the prevalance of industry evolution casts doubt on the assumptions underlying previous studies which have looked at the experience–outcome link — in product development for sure, but also possibly in other contexts such as alliances, acquisitions, and so on.

My finding that the benefits of depth and breadth of experience are contingent on technology and industry life cycles, taken together with broad management research and evidence on competitive shifts through industry evolution (Teece, 1982; Tushman and Anderson, 1986; Agarwal et al., 2002), implies that the conflicting and weak results of earlier studies are due to partly unobserved differences in technology and industry life cycle changes. Future work should give more direct attention to the evolutionary context in which product development occurs. Another possibility is to consider the evolutionary context in which experience itself is accumulated. Experience may have different effects according to the evolutionary context at the time it is accumulated.

Second, one of the most interesting insights coming from this study is the changing nature of the experience breadth and industry life cycle relationship in an industry's late maturity stage, termed its "de-maturation" period (Abernathy et al. 1983). This finding reaffirms the importance of considering this very late period in the industry life cycle as separate from the usual maturation period. The de-maturation stage has quite different characteristics, as set out in Klepper's (1997) review of industry evolution studies and discussed in Adner and Levinthal's (2001) explanation of the demand-side of industry evolution. An industry in de-maturation will often display intense innovation activity and an unusually high survival rate for the very latest entrants. These observations suggest that the traditional growth stage vs. mature stage dichotomy could be extended to include this later period of the industry life cycle. It is important to note that industries do not re-enter a growth period *per se* as there are limited opportunities for scale economies and process innovations. Instead, this stage represents a mix of growth and maturity periods in which incremental and process innovations play as critical a role as they do in the maturity period, and product innovations—and possibly more than just incremental innovations—become important for competition again. My findings agree with those of Klepper (1997) and Adner and Levinthal (2001) and show that the de-maturation period could be more prevalent than previously thought. However, a question remains: what triggers a de-maturation phase? Although some studies pointed towards endogeneous reasons for the shift to "de-maturation" period (Adner and Levinthal, 2001), Klepper (1997) and Tripsas (2008) point to exogenous changes in the market that drive such a change in the industry context. One particular change that could drive this shift to de-maturation in the video game industry could have been "rise of sophisticated cross-platform development tools called "middleware" "(Corts and Lederman, 2009; p. 125). These tools help automate the process of developing code and content (Tschang, 2007), and therefore firms compete more similar grounds in terms of production technologies. This has likely pushed firms to make more innovative games in terms of content as programming has been handled much faster with the help of such tools. In turn, industry conditions reward both incremental and major innovations. Future research is needed to fully understand reasons of observing the de-maturation phase.

In this dynamic context, publishers need to develop products into both new and old genres. How can a firm grow its experience base, and still benefit from its previous product development experiences? The solution exists within these very contingencies. On the one hand, publishers can develop new products in genres in which they have less experience, early on in the technology life cycle — thereby broadening their experience base for the future. At the same time, they can invest in their existing genres to further deepen their experiences and increase their chance of success in later periods of the technology life cycle. Such a strategy maximizes the benefits that arise from deep experiences when the industry matures, because there is a positive effect of depth of experience in the maturity and de-maturity periods of the industry.[25] However, publishers should not neglect the importance of broadening their experience base, because breadth becomes important for product development success in the de-maturation period. The experiences of EA, Ubisoft, and THQ, which were described anecdotally in the results section, corroborate this discussion.

Naturally, this study has its limitations. First, a potential issue is unobserved heterogeneity in the dataset, which means that a firm's decision of where and when to develop a new game is not exogenous (Eggers, 2012). Publishers may in fact be aware of their advantages and deliberately build on their deeper experienced genres in order to benefit during the industry's mature period. However, I note that this requires a trade-off, since the firm also needs to broaden its experiences before de-maturation initiates. This study assesses when a firm may have advantage in developing a product in a given time and genre.

Second, the industry studied is a creative one in which firms need both novelty and familiarity in order to succeed (Lampel, Lant, and Shamsie, 2000). This feature may be especially significant in the de-maturation period, when innovation becomes important again. However, I also note that the relative importance of novelty and familiarity changes through

[25] Which are likely to stem from "rationalization" practices as explained in Tschang (2007). This refers to prioritizing process improvements and planning development over pure creativity, in order to manage the increasing size of video game development and marketing efforts.

time within the industry (Tschang, 2007), and I capture this effect through technology and industry life cycle changes. Finally, industry evolution studies have found a similar de-maturation pattern in traditional industries such as automobile manufacturing (Abernathy and Clark, 1985); hence, I do not think that the creative nature of the research setting is an important limitation of the current study.

In terms of generalizability, the mechanisms argued in this article are based on the literatures of learning and industry evolution, which have studied a wide range of industries. The benefits of breadth of experience arise from experience heterogeneity and development of higher level capabilities, which have been discussed or observed in many settings (Helfat and Raubitschek, 2002; Haunschild and Sullivan, 2002; King and Tucci, 2002; Schilling et al., 2003; Chen et al., 2012). The benefits of depth of experience arise from knowledge specific to a market or segment, which has also been explored in many industries (Helfat and Lieberman (2002). It could be true that some industries do not experience multiple technology life cycles, or even a traditional industry life cycle, but most industries experience at least one of these major evolutionary changes, which gives additional confidence to the generalizability of results.

In conclusion, prior research exploring the experience–product development performance link has implicitly assumed that industry context remains static. In comparison, my theory and results suggest that competitive shifts, due to forces of industry evolution, have a profound effect on whether depth and breadth of experience will improve product development success (or even undermine success!). I believe that proper consideration of industry evolution, by analyzing the co-evolution of firms and their experiences in changing industry conditions, has the potential to answer many old questions and revitalize our view of product development, organizational learning, and industry evolution.

CHAPTER 3 [26]

WHY DO NEW PLATFORM TECHNOLOGIES FAIL? THE PARADOX OF TECHNOLOGICAL SUPERIORITY

ABSTRACT

Technological superiority provides more functional value for users, and is a critical dimension that challengers can leverage to dethrone incumbent technological platforms. We argue that while technological superiority might help accelerating adoption on one side of the market by driving early user adoption, it also causes greater innovation challenges for complementors who face time compression diseconomies due to the learning of the new technological environment. This limits their contribution of complementary products, which creates unfavorable expectations and slows down platform adoption. Eventually, these platforms fail. We develop this logic conceptually through a qualitative analysis of the US video game console industry. A number of studies have documented a puzzling result that it is often the inferior technology to become the dominant standard. In the context of platform markets, our study highlights that what is perceived as 'superior' from a technological perspective is in fact 'inferior' from an ecosystem perspective that accounts also for complementors.

[26] This chapter is the result of joint work with Carmelo Cennamo.

"We recognize that our technical architecture has initially made Sega Saturn more difficult to develop for than other next generation formats, including the Playstation. But that is also why we know that Sega Saturn is a superior gaming platform".

– Tom Kalinske, CEO of Sega of America, August 1995

INTRODUCTION

Many high-tech markets are nowadays organized around platform technologies, which provide value to final customers not only through their standalone functionalities, but also by allowing third-party firms to build upon and develop complementary products that extend the reach and value of the core platform technology to users (see Gawer 2014 for a review). In essence, platform technologies give rise to standards at the industry level, which form a system of use (David & Greenstein, 1990; Katz & Shapiro, 1994), whereby final customers benefit from using the platform in conjunction with its stable of complements (Choi, 1994).

The literature on technological standards battles (see Suarez, 2004 for a review), which are analyzed under labels of dominant designs (e.g., Anderson and Tushman, 1990), technological trajectories (e.g., Dosi, 1982), standards (e.g., Katz and Shapiro, 1985), or platforms (Gallagher and Park, 2002), has highlighted different factors that may lead a technology to win (or being locked out from the market), with particular emphasis on technological features such as compatibility with the dominant standard and technological superiority (e.g., Rosenbloom and Cusumano, 1987; Schilling, 2002, 2003; Sheremata, 2004; Suarez, 2004). In particular, technological superiority – "how well a given technology performs vis-à-vis competing alternatives" (Suarez 2004: 276) – has been considered a critical success factor for new technologies aspiring to dethrone the dominant technological standard (Sheremata 2004; Suarez & Kirtley 2012; Schilling, 2003; Christensen, Suarez, and Utterback, 1998). By providing more benefits to final customers that compensate the costs they bear to switch from the incumbent to the new technology, technological superiority may generate an "innovation shock" (Argyres et al. 2015) in demand and induce adoption of the new technology.

Consistent with this "user perspective", the economics literature on platform competition has highlighted the importance of a platform's user installed base as a primary factor for a platform technology to eventually emerge as the dominant platform in the market – which has been referred to as the *winner-takes-all* hypothesis (Armstrong, 2006; Lee et al., 2006). The focus in this literature is generally on the importance of network externalities – adoption of the platform by users creates positive feedback effects for developers of complementary products, inducing other users to adopt the platform (Eisenmann et al. 2006; Evans 2003; Rochet & Tirole 2006). In this regard, technological superiority of a platform would provide direct benefits for users to adopt the new technology, and may generate early lead in the market and thus increase the likelihood of success.

Both literatures thus extensively focus on the users' benefits as major driver of a technology success, fuelled by "bandwagon effects" (Katz & Shapiro, 1992), "community support" (Wade 1995) or "winner take all" (Eisenmann et al. 2006). An implicit assumption in the two-sided platform literature is that, when a new platform arrives to the market, complementors may be ready to build complementary products for it as long as users adopt the new technology. The problem, in other words, is a market problem: implementing market penetration strategies to create positive network externalities. Designing a technological platform such that its functionalities offer enough value for users to start adopting it would help jump start this adoption process. Yet, evidence exists in the standards literature that often is the "inferior" technology that wins, usually because of wider support from complementors (Anderson et al. 2014; Rosenbloom & Cusumano, 1987; Tushman and Anderson, 1986; Wade, 1995). Why do complementors choose to support an "inferior" technology remains though a puzzle, challenging the major theoretical views in the literature. Scant work exists on how these "communities" or networks of complementors emerge and evolve around the core technology. A small set of studies has recently shown that when complementors face innovation challenges, the core technology may face adoption growth constraints (Adner & Kapoor 2010; Cennamo & Santaló, 2013). In other words, superior technologies may still fail because of limited availability of complements (Schilling 2002). Missing though is an understanding of why this happens.

In this study we argue that technological superiority entails "shadow costs" for complementors, particularly in terms of learning and commitment of resources under high uncertainty, which limit value creation from the supply-side of the platform market. Since we are interested in the emergence and growth of the whole platform ecosystem, we focus on the early market stages of challengers' new platform technology vis-à-vis incumbents' where "windows of opportunity" can be leveraged by technological leapfroggers (Christensen et al., 1998; Schilling, 2003). We argue below that the higher the technological gap between the new generation and the incumbent platforms, the higher the challenges for complementors to embrace the new platform technology and build complements for it. This would eventually put a brake on the subsequent adoption of the platform, which, despite early momentum, may fail to reach the mass market. Instead of looking at the aspects that enable the platform to gain momentum we rather focus our attention on what limits the capacity to sustain and leverage such momentum and turn the platform into a mass-market product. The research question we try to answer is thus: *why do new-generation platform technologies fail despite early momentum*?

We start by revisiting the concept of technological superiority. So far, this concept has been treated mainly in terms of benefits to users. A noticeable exception, Anderson, Parker and Tan (2014) discuss, and formally model, the potential tradeoffs platform owners face between investing in the technology to provide more functional benefits to users and investing in tools to benefit complementors by facilitating their production of complements. Building on this insight, and other studies from the information systems literature that point to increased programming complexity and learning costs that may be associated with superior technologies (e.g., Baldwin, MacCormack, and Rusnak, 2014; Venkatesh, 2000; Xu et al., 2010), we expand the concept of technological superiority to also include benefits (or constraints) that the new technology offers to complementors.

We then explore this revisited construct in the context of the video game industry, which shows the introduction of different platform technology generations, high variance in platform leadership and several failures of platforms pioneering the new generation of the platform technology. Many of these platforms had some user base and complements available, showing that they gained momentum; nevertheless, they fail. Building on our reading of these failures, we develop a conceptual framework identifying three factors – time compression diseconomies, resource commitment, and lock-in problems – affecting complementors' learning of the new technology programming environment, and thus co-specialization and value creation, which consistently contributed to platform failure of the different players in the industry. This was particularly the case when the functional gap with the previous generation technology was higher. In fact, one of the major finding from our study is that breaking with the current technology trajectory by moving up the frontier of the technology may be major obstacle for the emergence of the ecosystem. Technological superiority, while it might enable innovation shocks on the user demand side, might represent a “shadow barrier” for complementors’ support on the complement supply side.

THEORETICAL BACKGROUND

Technological Superiority

Dominant design (Utterback and Abernathy, 1975; Tushman and Anderson, 1986) emerges through complex relationships between social and economic factors. One of the most fundamental firm-level factors considered in technological battles for dominance is the superiority of a technology (e.g., Schilling, 1998, 2003; Suarez, 2004). Although technological superiority alone is not a sure mean to win the battle for technological dominance, it has been conceptualized as an important firm-level advantage in the battles for dominance. For example, Suarez (2004: p.276) argues that: “*Other things being equal* [emphasis added], the better a technology performs with respect to competing technologies, the higher the likelihood that it will become dominant.” Schilling (2003: p.17) claims that: “…if the new entrant is unable (or unwilling) to make its technology compatible with the existing standard... functionality advantage must offer *so much value* [emphasis added] to the customer that it exceeds the combination of functionality installed base, and complementary goods value offered by the incumbent technology standard.”

A specific interest in studies on technological dominance has been in industries where network externalities are prevalent (Katz & Shapiro, 1986). Such positive consumption externalities mean that the value derived by a user increases with the number of other users. Factors that determine success and failure in technological battles may often have different implications when network externalities are involved in (Schilling, 2002). It has been argued that in an industry where network effects are present, early entry is more rewarding in case of technological superiority as it will help to draw users early on to the platform. Sheremata (2004) advance that investing in radical innovation that would enhance the functionality gap of the new technology compared to incumbents as the best option for new entrants to dethrone incumbent standards. Schilling (1998: p.278) theorizes that, "…when a technology yields a dramatic improvement over previous generations or different technologies that serve similar functions, that technology will more rapidly gain customer acceptance". Studies on network externalities highlight the importance of gaining early user installed base, which can be interpreted as "a reflection of its [i.e., technology] intrinsic value - or, alternatively, as an indication of the "brand" value of being associated with a superior product" (Brynjolfsson & Kemerer, 1996: 1629).

Most studies have conceptualized superiority of the technology mainly in terms of technical features that affects the output of a technology. Since focus is on the output, this essentially implies that technological superiority could be a key driver for user adoption of the technology. This shall be the case when technology has value on its own. Yet, when it requires additional components or complements to generate full benefits for the final customer, technical features are not sufficient as they represent only one part of the whole system (Adner & Kapoor, 2010; Anderson et al. 2014; Xu et al. 2010). Nonetheless, authors have advanced that even in these contexts, since new technologies bear a disadvantage in terms of user installed base or complements, they will have very limited chances of succeeding unless they provide users with greater functionalities (i.e., technology superiority) that compensate for the lack of installed base or complements (e.g., Schilling, 2003; Sheremata 2004).

Technological Superiority Revisited

Platform technology innovations do not take place in a vacuum; their success depends on other actions of ecosystem members (Adner and Kapoor, 2010), which include users but also and importantly complementors. According to such an ecosystem view, value creation from platform innovation is severely reduced if complementors experience innovation challenges in supporting the platform (Anderson et al. 2014; Cennamo & Santaló 2013). Technology superiority of the platform may thus have limited or no value to consumers if complementary innovation is lacking because of complementors' innovation challenges.

In these contexts, where technology is only one component within a system of use, albeit a central one (Gawer 2014), when assessing the superiority of a technology *system* one should not only consider how the key attributes of the core technology benefit users (compared to incumbent technologies) but also how these attributes benefit (or hamper) complementors' ability to respond timely to such game changer innovation and build compelling complementary products. Accordingly, we conceptualize technological superiority not only in terms of user (dis)functionalities but also in terms of *complementor (dis)functionalities*. We are grounding our ideas on two established literatures: technology acceptance model in information systems literature (e.g., Venkatesh, 2000; Xu et al. 2010), and complexity originated in systems theory literature (e.g., Simon, 1962; Baldwin, MacCormack, and Rusnak, 2014).

Technology acceptance model, originally developed by Venkatesh (2000), and refined in later studies (Venkatesh & Davis, 2000; Venkatesh & Bala, 2008), explains how users will adopt and use a technology. Two main factors on the user side are identified as critical for adoption of a new technology: (i) perceived usefulness, and (ii) perceived ease of use. Perceived usefulness is the degree to which an individual believes using the technology help that individual to reach his/her goal (Venkatesh and Davis, 2000). The greater the expected gains, the greater the intent to use the new technology. Perceived ease of use is the degree to which using the new technology is free of effort (Venkatesh and Davis, 1996).

Recently, this model has been also used to understand when users will switch to a new platform technology (Xu, Venkatesh, Tam, and Hong, 2010): usefulness, enjoyment of use, and perceived superiority of services obtained from the platform have been highlighted as important factors. In general, this literature confirms previous conceptualizations of user-related technological superiority and its role in user adoption.

On the other hand, literature on system theory explores how connections and hierarchies forming the system itself create complexity (Baldwin, MacCormack, and Rusnak, 2014). Complexity of architectures are generally measured by identifying linkages existing between different elements in the system (Simon, 1962; Alexander, 1964) and it has been thought to increase as number of interconnected components and subsystems increase (Dibiaggio, 2007). As complexity, therefore linkages between parts of the system, increases, it becomes more costly and harder to understand and verify the workings of a given system, due to the nested hierarchy of decisions required for performing the task. Indeed, in software engineering, complexity has been defined as: "the degree to which a system or component has a design or implementation that is difficult to understand and verify" (IEEE Standards Board, 1990) and it is measured by lines of code (LoC) or other measures based on relationships between components in a system (Lagerstrom, Baldwin, MacCormack, and Dreyfus, 2014).

This literature on complexity provides us with the important insight that a system's architecture may involve higher costs for those that need to use the core technology of the system, or platform, to create complementary goods for users. For instance, in a recent theoretical model, Anderson et al. (2014) advance that investing in technical functionalities to enhance performance of a new platform technology could be a selling point for users, but would also make the system more complex and require developers to make large investments to produce complements for these new platform technologies.

Building on these studies, we conceptualize superiority of a technology system in terms of the benefits it offers to both users and complementors. In particular, we consider technology's usefulness, enjoyment, superiority of services and hardware capabilities/potential as user-related benefits, and a technology's number of lines of codes, interconnected components, and development cost per unit performance as indicators of system complexity, thus technology's (dis)functionalities for complementors. Table 8 provides a list summary of various definitions of user and complementor (dis)functionalities.

RESEARCH METHODOLOGY

Due to limited theory about platform emergence and evolution (Jacobides, Cennamo, and Gawer 2015) and why platform innovations fail, we conducted an inductive multiple case study (Eisenhardt, 1989; Yin, 1994). Such an inductive study is useful when existing theories fall short of answering the existing question and especially in cases question is related to a process or evolution over time (Langley, 1999; Hannah, 2014).

We chose to study video game consoles, such as Sony's PlayStation or Sega's Genesis, which serves as platforms on which game titles are developed by complementors (on the sellers' side) and these are consumed by (played by) users (on the buyers' side). First, they are a quintessential example of platform markets that shows very strong support for cross-sides network effects and pricing strategies (e.g., Clements and Ohashi 2005). Second, they are technical devices,

TABLE 8
Summary of definitions on User (Dis)functionality and Developer (Dis)functionality

Reference	User (Dis)functionality Factors	Explanation
Venkatesh, 2000	Technology Acceptance Model - Perceived Usefulness	The extent to which a person believes that using a technology will enhance her/his productivity
Xu et al., 2010	Technology Perceptions - Usefulness	"The degree to which an individual believes that using the technology (i.e., ICT platform) will help him or her to attain gains in personal productivity" (Venkatesh and Davis, 2000; Xu et al., 2010).
Xu et al., 2010	Technology Perceptions - Enjoyment	Enjoyment is defined as the extent to which the act of using the new ICT platform is perceived to be pleasurable in its own right, apart from any expected performance consequences (Venkatesh, 2000).
Xu et al., 2010	Technology Perceptions - Superiority of services	The extent to which the new platform is expected to support and provide services that are better than those available in an existing platform generation.
Anderson, Parker, and Tan (2014)	Platform Performance	A vertically differentiated dimension of quality (better graphics and processing capabilities) - Increases end users' utility
Reference	Developer (Dis)functionality Factors	Explanation
Simon (1962); Alexander (1964)	Complexity	Linkages existing between different elements in the system in a network representation
IEEE Standards Board (1990)	(Software) Complexity	The degree to which a system or component has a design or implementation that is difficult to understand and verify
Lagerstrom, Baldwin, MacCormack, and Dreyfus (2014)	(Software) Complexity	Lines of Codes
Lagerstrom, Baldwin, MacCormack, and Dreyfus (2014)	(Software) Complexity	Relationships between components in a system
Dibiaggio (2007)	Complexity	Number of interconnected components and subsystems
Anderson, Parker, and Tan (2014)	Development cost per unit performance	Game creation for higher-capable hardware is more complex - Increases complementors' costs

so they allow us to have a variance on their technological superiority and how it affects network emergence in earlier stages of competition. Moreover, having quantifiable performance differences between consoles allows us to objectively assess how each console is positioned in terms of user and developer (dis)functionalities. Third, there have been multiple generations of platform releases and several changes in market leadership that allows us to separate challenger that "win" from challengers that "lose". Fourth, availability of performance measures in terms of installed base and game releases allows us to easily track each console's evolution and their eventual failure or dominance.

Our analysis covers all major consoles released from 1988 until 2012 – this excludes current generation of consoles recently initiated with the release of Wii U by Nintendo. During this time period, a total of 20 consoles (including 2 console add-ons released by Sega) have been released. We have treated each console as a separate platform case, and tracked its evolution, performance as well as technical characteristics. Video game consoles have been historically divided into different generations based on the word instruction length (in bits), CPU speed and amount of RAM (de Vaan, 2014; Forster, 2005). Table 9 lists these consoles, according to their technological generation.

Data Sources

We relied on several data sources to understand the evolution of each platform in our sample, and their eventual performance: (1) books that have documented the history of the video game industry as well as individual console producers (Kent, 2001; Pettus, 2013; Harris, 2014); (2) *retrospective* section of the various issues of *Retrogamer Magazine* where each platform in our sample is explored in-depth through interviews done with key managers and game developers that have worked for each platform; (3)[27] publicly available information in video game industry websites such as arstechnica.com, 1UP.com, Gamespot.com, Gamasutra.com, IGN.com as well as articles on video game consoles (Schilling, 2002; Corts & Lederman, 2009; Clements & Ohashi, 2009). This allows us to compare what has been reported on historical events and *ex-post* stories

[27] In case a source on the internet was not accessible, we have reached the website by using Internet Wayback Machine (http://archive.org/web/)

TABLE 9

Sample Consoles in US Video Game Industry (1985-2012)

Console	U.S. Launch Date	Platform Parent	CPU bits	MHz	RAM	Launch Price
Generation 3						
Nintendo Entertainment System (NES)	Oct. 1985	Nintendo	8-bit	1.8	0.002	$199
Master System	Oct. 1986	Sega	8-bit	3.54	0.008	$199
Generation 4						
Genesis	Aug. 1989	Sega	16-bit	7.6	0.064	$190
Turbografx-16	Aug. 1989	NEC/Hudson Soft	8/16-bit	7.16	0.008	$199
Super Nintendo Entertainment System (SNES)	Aug. 1991	Nintendo	16-bit	3.58	0.128	$199
Sega CD (Add-on for Genesis)	Oct. 1992	Sega	16-bit	12.5	0.75	$299
32X (Add-on for Genesis)	Nov. 1994	Sega	32-bit	23 X 2	0.512	$159
Generation 5						
3DO	Oct. 1993	3DO	32-bit	12.5	2	$699
Jaguar	Nov. 1993	Atari	32/64-bit	26.6 X 2	2	$249
Saturn	May. 1995	Sega	32-bit	28 X 2	2	$399
Playstation	Sept. 1995	Sony	32-bit	33.87	2	$299
Nintendo 64	Sept. 1996	Nintendo	64-bit	93.75	4 (Unified)	$199
Generation 6						
Dreamcast	Sept. 1999	Sega	128-bit	200	16	$199
Playstation 2	Oct. 2000	Sony	128-bit	294.9	32	$299
Xbox	Nov. 2001	Microsoft	Pentium II	733	64	$299
Gamecube	Nov. 2001	Nintendo	128-bit	485	40	$199
Generation 7						
Xbox 360	Nov. 2005	Microsoft	Power PC	3200 x 3	512 (Unified)	$299
Playstation 3	Nov. 2006	Sony	Power PC	3200 x 7	256	$499
Wii	Nov. 2006	Nintendo	Power PC	729	88	$249

of these managers, which allow us to evade both ex-post rationalization and deducing wrongly from history of events.

In general we relied more on video game related sources as major press tend to focus on most known aspects of the industry (e.g., pricing, winners, latest hits etc.). In particular, interviews with key executives and developers, mostly within the retrospective section of Retrogamer and Video Game websites allowed us to understand perspectives of both market issues as well as development related issues. We also accessed any other publicly available yearly reports and 10-K reports to triangulate our findings. All these in-depth sources of archival data allowed us to build a comprehensive and accurate history of each platform in our sample.

Data Analysis

We have started data analysis by combining our various data to build the historical case of each platform in our sample. In combining these data, we directed our attention and understanding on the emergence and evolution of each platform system and the factors that caused them to fail (or succeed). We focused in particular on important events and choices related to user and developer sides of each platform, and competitive dynamics between old and new-generation platforms, as well as between platforms of same generation.

We identified three main constructs to categorize problems of failing platforms: (i) time compression diseconomies, (ii) resource allocation problems, and (iii) lock-in problems. Time compression diseconomies will be present due to impossibility of compressing learning in a short time period even with an increased allocation of resources (Dierickx and Cool, 1989). Resource allocation problems will be present due to less current value of the new platform for the complementor, inducing the complementor to allocate second-tier resources for the platform. Lock-in problems are simply the case that, although the market uncertainty is solved to some extent with users adopting, the complementor will be unsure if it pays off to invest and learn for this new platform, and in case it doesn’t work, there will be an increased risk off lock-in.

Measures

We needed two kinds of measures to test our theory. On one hand, we required to show the performance of various platforms in order to see if they have failed or succeeded. For this we relied on the main measure of success of a platform: installed user base at a given point of time (relative to competing systems).

On the other hand, we needed to also map the positioning of consoles in terms of user and developer (dis)functionalities. In order to do so, we have first collected data about the technical specifications of each platform. As studies on technology adoption suggest that benefits for users mainly come from perceived usefulness and power performance, we have used main technical components of a platform, consisting of its CPU, Graphics Card, RAM, Sound Card and its media format (cartridge, CD-ROM, DVD-ROM etc.) to capture benefits for users. Capturing platform (dis)functionalities for developers requires identifying factors that reveal in our context how difficult for developers to program games for the whole platform system. With this in mind, we have captured complexity of a given console with 3 main specific characteristics: (1) Total Number of Non-Sound Processors, (2) Requirement of using parallel processing to fully utilize the hardware, and (3) the default development environment for the platform. Difficulties of programming due to number of non-sound processors and using parallel processing are similar; it increases the need to coordinate the flow of processes undertaken by either various chips in the case of number of processors, or central processing units in the case of parallel processing. This in turn, increases complexity, as we highlighted above that complexity increases as the linkages and connections between different nodes of a system increases. Development environment, on the other hand, affect the difficulty of development either by requiring the programmer to code everything from scratch, or allowing an easier interface where developers could use ready-made tools instead of coding at length (an analogous comparison could be made by considering web page design through HTML coding vs. using a WYSIWYG "What You See Is What You Get" web page creator program where you click and drop elements of a page). For each generation, we map the technical specifications of each console along these two dimensions – user functionalities and developer (dis)functionalities. This mapping is done as follows: (a) for the user benefits, we calculated the rate of improvement in terms of CPU and total RAM of each console compared to the dominant console of the previous generation. In addition, we created dummy variables if the console offers the latest optical media in the market (CD-ROM, DVD, Blu-ray), if the console offers the latest novelty feature among the consoles in its generation (internet connectivity, motion control), and if the console is backwards compatible (e.g., Xbox 360 is able to play Xbox games of previous generation). As a last step, we created a z-score for both CPU and RAM for all consoles in the next-generation (i.e., following the incumbent generation). These z-scores are summed with dummy values (with z-scores for CPU and RAM having weights of 1, and each dummy value having weights of 0.5) to calculate the total user benefits of each console. We followed a similar approach with the elements of console complexity to calculate total developer disfunctionalities each console brings.

TECHNOLOGICAL LEAPFROGGING IN THE US VIDEOGAME SECTOR

Fourth Generation Consoles (1989 – 1993)

The fourth generation has been characterized by improved graphics, sound, and computing capabilities (as can be seen by comparing 4th generation consoles with 3rd generation in Table 4), as well as by the start of well known “bit wars” (Harris, 2014). At the beginning of this generation, Nintendo was dominating the market with its third generation console, NES (Nintendo Entertainment System), having virtually all developers working for its platform. In the fourth generation, there were 3 consoles and 2 console add-ons releases. Early challengers were NEC and Sega, respectively with their Turbografx-16 and Genesis consoles. Subsequent releases of new consoles include Nintendo’s SNES (Super Nintendo Entertainment System) and 2 add-on releases by Sega to improve the technical features and market position of Genesis: Sega-CD and 32X.

Turbografx-16 and Genesis were released around the same time in US, August 1989, both trying to challenge the incumbent NES by technologically leapfrogging it. Though Turbografx-16 was considered a 16-bit console due to its graphic processors, its main processor was essentially 8-bit, as NES, but had four times the clock speed and main memory of the NES. Most important technical edge of Turbografx-16 was its graphics capabilities. Its 2 special graphics processors were able to show up to 482 colors on screen at a time, compared to 25 colors of NES. On the other hand, Genesis was the most advanced console in overall until Nintendo responded by releasing SNES two years later. As can be seen from Tables 9 and 10, NES was based on an 8-bit 1.8 MHz speed processor and had 0.002 MB Ram, while Genesis had a 16-bit 7.6 MHz processor and had 0.064 MB Rams. Genesis was able to show 64 colors, drastically improving upon NES’ graphic capabilities. Also, Genesis had the same processor 8-bit processor of its older generation Sega Master System, and could use it for full backwards compatibility.

SNES arrived as a late response by Nintendo in August 1991, and it offered major improvements with respect to all other consoles. It had a 16-bit 3.58 MHz processor, only outmatched by Genesis, but it was able to show 256 colors out of 32,768 color palette, giving the highest color palette available for games –the actual number of colors on screen was only outmatched by Turbografx-16. It had double main memory of its close rival, Genesis, and it offered the most advanced sound capabilities in a console by that time (sound processor was developed together with Sony, which eventually leveraged this acquired knowledge of the industry to develop its own console, PlayStation, later on).

Sega released Sega-CD and 32X add-ons (October 1992 and November 1994 respectively) to enhance capabilities of Genesis console. Sega-CD was an early attempt to use CD as a media to store games, instead of cartridges, but it added minimal technical functionalities to the core console technology (and therefore we do not consider it for our analysis). Released at the end of the fourth generation, 32X had dual 32-bit processors, over 32,000 colors and four times the memory of SNES.

Main consoles in this generation are characterized by similar development requirements through assembler heavy programming. An assembly language is a specific type of low-level computer programming language, specific to each console, whose knowledge is fundamental for the game developers to build a game for the console[28]. Although these consoles represented an important jump with respect to 8-bit consoles they replaced, such as NES, there were 2 reasons such jump didn't ensue into important developer disfunctionalities, especially for early challengers. First, NES was technically outdated by the time early challengers came at 1989, and developers had already a good amount of experience with programming for 16-bit processors. Both Atari ST and Amiga 500 personal computers, which were based on the same 16-bit processor used in Sega's Genesis, were released around 1985-1986 and they were highly popular for their video games respectively in US and Europe. This allowed many developers to have experience with 16-bit

[28] This programming language consists "mostly of symbolic equivalents of a particular computer's machine language. Computers produced by different manufacturers have different machine languages and require different assemblers and assembly languages. [P]rogramming in assembly languages requires extensive knowledge of computer architecture" (http://www.britannica.com/EBchecked/topic/39243/assembly-language, accessed 24 February 2015).

computer-based game development by the time challengers arrived to the console market with similar developing technology. Second, early challengers Turbografx-16 and Genesis, both had to sustain their game development activities internally when they were released since NES had most of the developers tied in exclusivity contracts that forbid them to switch to competing consoles for two years (Evans, Hagiu, and Schamalansee, 2006). By the time developers switched to these challenger consoles, this jump was quite incremental for their skills. For all these reasons, developers needed to make equal learning investments for developing games to any console in this generation, meaning that they incurred the same cost and difficulty for development whichever new console of fourth generation they choose. Since developer (dis)functionalities were equal between these consoles, merits of these systems were based exclusively on their user functionalities, which meant their technical power.

Looking at add-ons, Sega 32-X is an interesting occurrence. The next generation console by Sega, Saturn, was released in Japan the day 32X, the add-on for the current console, was released in US. Saturn was going to be released in US just one year after Japan, giving 32X only one year to go. This proved detrimental for the prospects of the add-on for two reasons. First, when a new programming technology is released, developers need to learn a new set of capabilities, which can be cumbersome as evident in the following quote: *"we're still on the 12 month cycle. Every time there's a new hardware generation, we have huge struggles making it work"* (Anderson et al., 2014: 154). Second, because of these difficulties and the limited residual life of the console, many developers ended up not using the additional hardware capabilities provided by the add-on. Sega of America's vice president of technology at the time, Marty Franz recalls in an interview:

*"*I think the real issue was timing [emphasis added]*; the games in the queue were effectively jammed into a box as fast as possible, which meant massive cutting of corners in every conceivable way. Even from the outset, designs of those games were deliberately conservative because of the time crunch. By the time they shipped they were even more conservative; they did nothing to show off what the hardware was capable of" (McFerran, 2012; p.243).*

32X offered tremendous capabilities but, because of timing issues, developers could not invest into new learning and experimentation, rather pressed to have games completed as fast as possible. This problem can be also detected in the same interview, when discussing why 32Xs' sound system has never been utilized:

"Developing a new audio engine was probably deemed not worth the investment by developers. The 32X was destined to be a short lifespan product. The developers put the dollars to the screen and saved money by not enhancing the audio" (McFerran, 2012: 243).

Performance Implications

At the end of the 1992, Sega sold 6.9 millions of Genesis, while Nintendo sold 4.2 millions (Shankar and Bayus, 2003) of SNES, and NEC`s Turbografx-16 ended up selling only around 2 million[29]. As an add-on, Sega 32X was sold only a little above 650,000 for over 8 million Genesis user base. Towards the end of the generation, SNES trumped Genesis in sales. A similar pattern in performance can be also seen in terms of quantity and quality of game releases. Genesis and SNES offered a high and similar number of critically acclaimed hits, 59 and 57, respectively, though game sales were higher for SNES (46 titles with over 1 million sales). Turbografx-16 on the other hand, had only 7 critically acclaimed hits (that received low sales due to low installed user base of the console). In terms of the quantity of game releases, SNES had close to 650 third-party games, while Genesis followed it with 513. On the other hand, Turbografx-16 had only 32 third-party game releases. Contrary to the main console, Genesis, 32X had a dismal market performance. In total, there were 35 game releases, and 19 of these were just minimally modified versions of games made for Genesis. Table 10 lists information on developer disfunctionalities and game release performance.

Why did SNES and Genesis succeed? Simply put, they both offered technological superiority in the classical sense the literature has referred to –in terms of user functionality. Since consoles in this generation had minimal and similar developer disfunctionalities, technological superiority were mainly based on the user functionality dimension. In 1989, Genesis was the superior console, and led the market until early 1993, while SNES was the superior console after its release in 1991, and gained market leadership through 1994.

[29] http://www.usgamer.net/articles/turbografx-16-at-25-remembering-the-little-pc-engine-that-could

Why did Turbografx-16 and 32X failed? Compared to Genesis, which released around the same time, Turbografx-16 was a technically inferior console offering more limited user benefits. On the other hand, 32X proved to be "inferior" because of developer disfunctionalities. On a technological prowess basis, 32X was clearly superior to any fourth generation console, being in fact closer to fifth generation consoles. Yet, its' problems with developers left this add-on with most of its power untapped. Essentially, game developers found it difficult to timely learn about how to effectively use this new programming environment and eschewed console-specific commitment of resources.

In sum, two main points shall be highlighted from the battle for the fourth generation console. One, absent developer (dis)functionalities, indeed technological superiority is critical factor in challenging incumbent platforms, and succeeding in the market, as it proved to be a powerful trigger of early user adoption. Two, Sega's 32X experience gives us the first glimpse of how developer (dis)functionalities could trigger problems that could nullify any value driven by user functionalities with technological superiority.

Fifth Generation Consoles (1993 – 1999)

This generation has influenced the Video Game Industry in a critical way. First, CD-ROM was a major improvement compared to ROM cartridges used by the consoles until that point. It offered more than 600 MB's of data storage while an average cartridge was offering up to 16MB's of data. Moreover, CD-ROM was much cheaper to produce, therefore reducing costs for developers as they generally had to pay to the platform owner such production costs (e.g., Nintendo was asking for paid minimum production limit to developers). As CD-ROM drives become affordable for the mass-market, it opened up new possibilities for developers to create new experiences. Second, development of hardware with 3D graphics capability was a major change in game designs, as 3D gaming has always been aspirational for platform owners and developers. Third, this generation represented the most technologically turbulent period with the highest number of entrants and competing consoles in the industry (de Vaan, 2014), each having their own quite different technology designs.

Consoles in this generation could be separated in two groups: pioneering challengers, 3DO and Atari, and following consoles by Sega, Sony, and Nintendo. 3DO's 3DO Interactive

TABLE 10

Summary of Complementor Disfunctionalities, and Game Release Performance for Fourth Generation Consoles

	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Example Quotes	Game Release Performance
Genesis	No	No	No	Early devices up to 32-bit machines had similar development requirements with assembler heavy programming.	Games available by the first Christmas (89'): 17 Games available in the first 12 months: 70 Exclusive games for the console: 355 Ported games from old generation devices for the console: 38 First-party (second-party) games: 168 (103) Third-party games: 513 Average quality of games (First & Second-Party): 74.67/100 Average quality of games (Third-Party): 71.49/100 # of hits: 59 (Critical Acclaim= 85+/100) # of hits: 17 (1 Million+ sales)
Turbografx-16	No	No	No	Early devices up to 32-bit machines had similar development requirements with assembler heavy programming.	Games available by the first Christmas (89'): 17 Games available in the first 12 months: 47 Exclusive games for the console: 56 Ported games from old generation devices for the console: 2 First-party (second-party) games: 76 (58) Third-party games: 32 Average quality of games (First & Second-Party): 81.11/100 Average quality of games (Third-Party): 78.5/100 # of hits: 7 (Critical Acclaim= 85+/100) # of hits: N/A (1 Million+ sales)
SNES	No	No	No	Early devices up to 32-bit machines had similar development requirements with assembler heavy programming.	Games available by the first Christmas (91'): 35 Games available in the first 12 months: 113 Exclusive games for the console: 406 Ported games from old generation devices for the console: 54 First-party (second-party) games: 49 (33) Third-party games: 648 Average quality of games (First & Second-Party): 82.81/100 Average quality of games (Third-Party): 71.95/100 # of hits: 57 (Critical Acclaim= 85+/100) # of hits: 46 (1 Million+ sales)
32X	YES	YES	No	"I spent weeks working with id Software's John Carmack, who literally camped out at the Sega of America building in Redwood City trying to get Doom ported. That guy worked ... and he still had to cut a third of the levels to get it done in time."	Games available by the first Christmas (94'): 13 Games available in the first 12 months: 35 Exclusive games for the console: 16 Ported games from old generation devices for the console: 19 First-party (second-party) games: 17 (8) Third-party games: 19 Average quality of games (First & Second-Party): 65.47/100 Average quality of games (Third-Party): 65.52/100 # of hits: 3 (Critical Acclaim= 85+/100) # of hits: N/A (1 Million+ sales)

Multiplayer (3DO) and Atari's Jaguar were released in October and November 1993, respectively, starting the Fifth Generation Console era.

3DO was more powerful than any other console in the market at the time of its release. It had a 32-bit RISC processor (a first for a console) with 12.5 MHz speed made by ARM, the main processor was also supported with a custom designed math co-processor to take the burden of repetitive calculations from the main processor. For graphics, it used 2 accelerated graphics co-processors, capable of advanced 3D capabilities for its own time. 3DO was also the first console that had CD-ROM only as a media; instead of cartridges that have been common previously (CD was only offered as an add-on in the previous consoles).

Atari's Jaguar was a 64-bit console (although contested) even when the first 32-bit machine was just released a month earlier (3DO) and it aimed to capture market through its hardware capabilities combined with low price for gamers. Jaguar featured a dual main processor structure with each working at 26.6 MHz and these two processors supported by a 16-bit general purpose processor, object processor, and a "blitter" coprocessor[30]. In total, there were five processors within Jaguar.

Sega Saturn was developed based on Sega's back then cutting edge arcade video game technology and upcoming Playstation's advanced 3D technical capabilities. Similar to Jaguar, Saturn also adopted a dual main processor structure, having two 32-bit 28.6 MHz processors. It also had 2 video processors, each with separate capabilities. Sega Saturn is generally considered to have a complex architecture, as it had eight processors making up the console.[31]

Sony's Playstation was a simple but powerful design that focused on 3D gaming. It had a single 32-bit processor with 38.8 MHz speed, and it had two specialized co-processors with the CPU, the one named "Geometry Transformation Engine" giving an edge to Playstation in 3D graphics when combined with Playstation's main graphics card.

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[30] Blitter is a specific type of coprocessor that helps with fast movement of graphical data through memory, and it was first invented for Amiga personal computers. http://www.google.com/patents/US4874164.

[31] "Saturn was a complex beast that used twin CPUs and another couple of video processing chips" http://www.theguardian.com/technology/2015/may/14/sega-saturn-how-one-decision-destroyed-playstations-greatest-rival, accessed 25 May 2015.

Nintendo 64 was the latest entrant to the Fifth Generation, and had the most technologically advanced console. It was the first console to have all 64-bit processor, running at 93.75 MHz. It also had the “Reality Coprocessor” which featured processors for its graphics capabilities. Perhaps the only part where Nintendo 64 was lagging behind competition was in its choice of using cartridges instead of CDs as a media. This was driven by two main reasons: on one hand cartridges allowed faster load time during playing games, while on the other hand Nintendo wanted to stop rampant piracy through CDs in that era.

3DO, the pioneer of the new console generation, struggled to obtain games from third-party developers by the time of its launch and the next follow-up months. Switching from 16-bit consoles to 32-bit consoles was indeed difficult for developers. Trip Hawkins, founder of 3DO, recently recalls:

“… but in fairness game developers were dealing with many new things and issues on this type of hardware… it turned out that even though many of the game developers were sure … that they going to make [games] for 1993 holiday season … didn’t really get to market until summer of 1994 … You could make the argument that that was the fatal blow” (Matthews, 2013; p.27).

As a result of these delays there was only 1 title (Crash ‘n Burn) when 3DO was released. Turning to Atari’s case, Jaguar, which released just a month later than 3DO, not only it experienced similar difficulties as 3DO’s, but it also created additional difficulties for developers with its complex and dual processor architecture. Full utilization of this console required to code the games to process everything in parallel for these processors at the same time (hence the name, “parallel processing”) which meant programmers need to code heavily in assembly language. Many developers considered this tedious, and an unnecessary hassle by the late 1993. Wayne Smithson, an old developer of DMA design (currently named as Rockstar - developer of best seller Grand Theft Auto series), explains:

"It was initially difficult to get anything decent out of it, it had more than one processor if I remember correctly ... [A]lso, it was the first time I had encountered parallel processing which took some getting used to, interleaving instructions to get the best performance out of the code was an art form in itself...” (Retrogamer, 2013).

This has been also admitted by Atari in their 10-K report of 1995:

"Atari attributes the poor performance of Jaguar to a number of factors including (i) extensive delays in development of software for the Jaguar which resulted in reduced orders due to consumer concern as to when titles for the platform would be released and how many titles would ultimately be available…" (Atari Corporation, 1995).

Yet, Atari Jaguar was an advanced console for its time. A recent release of a classic video game by a hobbyist coder for Jaguar has shown that the console could be considered quite powerful in its own time, given the right amount of investment to learn its specifics:

"It was like jumping into an alternate reality in the past where someone coded Another World on this computer," recalls Chahi [original developer of Another World]. "I was amazed by the quality of this version. Seb coded it in assembly language using the advantage of the Jaguar hardware. It is one of the best versions, clearly. The code is so well optimized that if the frame rate is not limited, it can run maybe at least five times faster than the original with all the enhanced graphics." (Crawley, 2013).

Yet, developers at that time experienced difficulties being this a novel programming environment and ended up using mainly the slowest, yet the most familiar of the console's processors, which resulted into production of titles that look similar in their quality and playing action to those released for old generation consoles SNES or Genesis (Retrogamer, 2013).

Sega Saturn had its own share of problems due to its complex architecture as well. Having 8 total processors, it offered high technical power, but mustering this proved particularly difficult. Sega's star game developer, Yuji Naka, asserts that:

"Trying to program for two CPUs has its problems. ... The two CPUs start at the same time but there's a delay when one has to wait for the other to catch up... I think that only one out of 100 programmers is good enough to get that kind of speed out of the Saturn." (Pettus, 2013; p.193).

Notwithstanding these issues, Sega hoped that investments over time to learn Saturn's architecture could give them an edge against Playstation. Tom Kalinske, back then President of

Sega of America in 1995, has openly stated to Sega community on the Usenet group in the early days of Saturn that:

"We recognize that our technical architecture has initially made Sega Saturn more difficult to develop for than other next generation formats, including the Playstation. But that is also why we know that Sega Saturn is a superior gaming platform ... We absolutely believe there will continue to be dramatic differences in software as our developers learn to unleash the power of Sega Saturn."[32].

Nintendo 64, although being easier to develop for than Jaguar and Saturn, still required some assembly level programming for its co-processor in order to get the most performance from its graphics capabilities. Genyo Takeda, back then Nintendo's hardware development chief, summarizes the issues with Nintendo 64:

"When we made Nintendo 64, we thought it was logical that if you want to make advanced games, it becomes technically more difficult. We were wrong," he admits. "We now understand it's the cruising speed that matters, not the momentary flash of peak power." (Newsweek, 2000, p.53).

On the other hand, there was a consensus on how easy it was to develop games for Playstation. For example, it has been highlighted that:

"Saturn may have been equal - even superior - to the PlayStation at the assembly language level, but Sony had effectively changed the field in its favor. Video game programmers were happily adjusting to coding in C, and didn't want to go back, leaving fewer studios willing to wrestle with the untapped potential of Saturn's dual-processor architecture." (Retrogamer, 2012).

This has been combined with other elements to ease game development for Playstation. Importantly, Sony used an operating platform that allowed developers to unleash the potential of the console easily: The software platform for the PlayStation was proprietary… designed exclusively for the PlayStation and optimized to make the most of the console's hardware capabilities (Evans et al., 2006: 130). Moreover, Sony was the first to provide developers with development tools to enable them to develop games for the PlayStation from the get-go. This

[32] Accessed from Google Usenet group archives, rec.games.video.sega, http://groups.google.com/forum/#!topic/rec.games.video.sega/VuUmORr-bw8, accessed 24 February 2014.

proved an important factor in Sony's success, making it easier to write games to the PlayStation than to the competing systems (Evans et al., 2006: 130-131). We have mapped user and developer (dis)functionalities for all consoles of this generation in Figure 10.

Performance Implications

Performance of these consoles varied highly, but two big players emerged by the end of 1999, the more dominant Playstation, and the follower Nintendo 64. Early entrants were the first to fail. Atari Jaguar sold only around 250,000 units, while 3DO was able to sell around 700,000 units[33] during their lifetime. Sega Saturn, contender of the market when it was released head-to-head with Playstation, sold only close to 2 million units. Playstation sold over 26 million units by the end of 1999 (Sony Corporation, 2014), and Nintendo 64 sold close to 15 million units (Nintendo, 2014). As for game-related performance figures, Atari Jaguar's, 3DO's, Sega Saturn's, and PlayStation's game release numbers in their first 12 months reflect the easiness or development difficulties of each console: Jaguar had 17 titles, 3DO had 71 titles, Saturn had 53 titles, and PlayStation had 133 titles. Nintendo 64 had an unusual low number of titles, 24, but these were of extremely high quality. Indeed, in terms of quality, Nintendo had 41 critically acclaimed hits, compared to Saturn's 21; Atari had only 2, and 3DO had 7 hit games; PlayStation, instead, had over 90 critically acclaimed games released for the console. Tables 11 and 12 summarizes information on game release performance and developer disfunctionalities respectively.

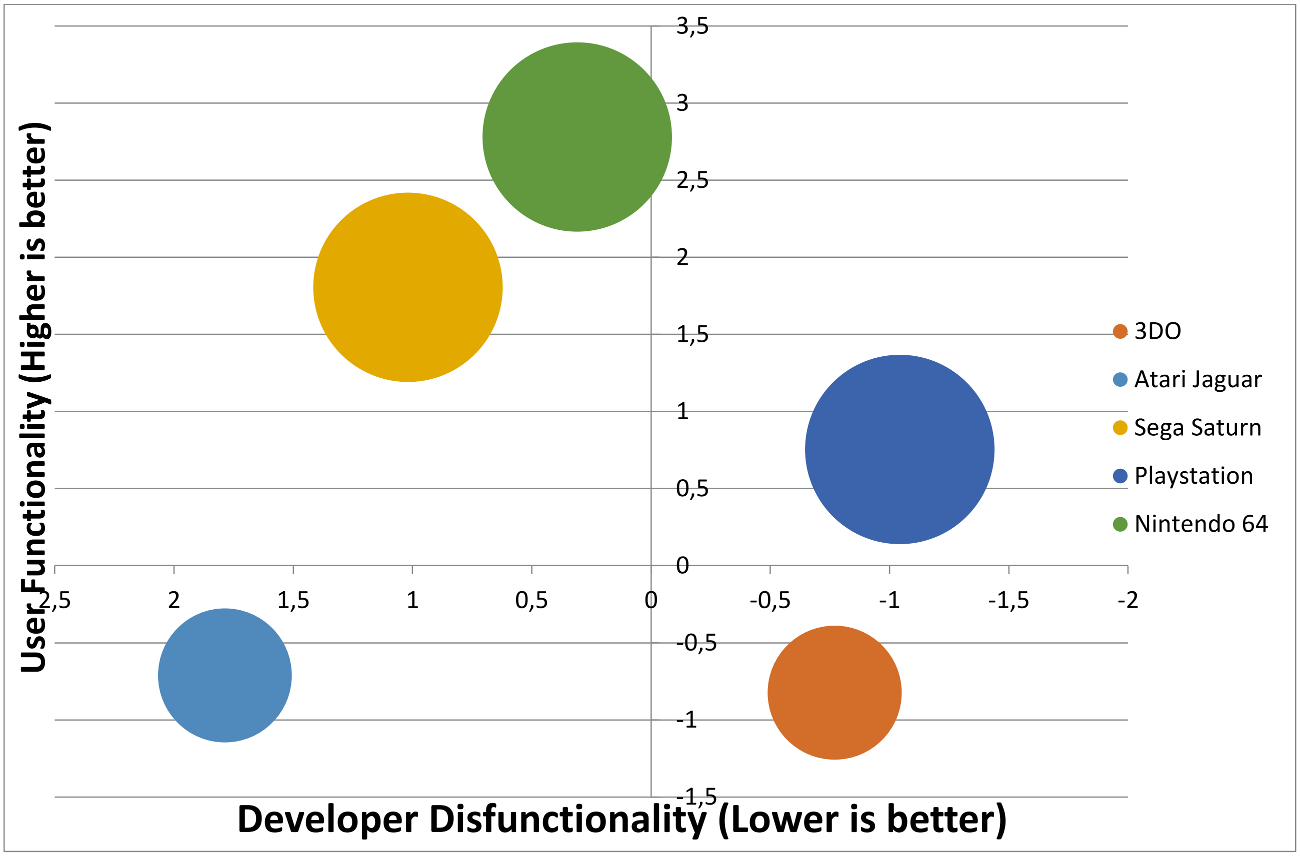
Why did Playstation and to a lesser extent, Nintendo 64 succeeded? Playstation was not the most capable hardware at the time, even before the release of Nintendo 64; Saturn was thought to be more complex, but possibly a better console (Pettus, 2013). Success of Playstation has been attributed to its easiness of development and support tools for developers, as much as its balanced hardware for early 3D gaming as exemplified by this quote:

"PlayStation had a single processing chip with a 3D geometry engine in its CPU. This processor, along with the excellent development tools Sony made available, made PlayStation extremely easy to program." (Kent, 2010; p.518).

[33] Since 3DO was produced under license by many manufacturers, there is no exact number for 3DO.

FIGURE 10

Dimensions of Technology: Technological Superiority as User Benefits and Developer Costs for 5th Generation Consoles



Nintendo 64 presented some developer disfunctionalities. Yet, because of its user functionality and Nintendo's in-house game development unit that produced hit titles such as Mario 64 or Pilotwings 64, the console received some noticeable sales.

Why did 3DO, Jaguar, and Saturn fail? Although 3DO was fairly easy to develop for, it offered low user functionality, and was relatively expensive for users. Bearing also this market uncertainty, developers delayed their game production for the console –this made 3DO lose momentum, and eventually fail. Jaguar failed because it had a too complex structure for developers, which caused delays and low quality games. Similar issues can be also seen in Sega's Saturn, which resulted into lack of third party support.

This generation represents one of the most turbulent periods in the console industry. Interestingly, this generation has been characterized by architecturally complex hardware except for one console that was generally accepted to be fairly easy to work with, Sony's Playstation. It became clear, *ex post*, that those consoles that had more raw power, yet more complex architectures were generally "losers". On the other hand, Playstation was aimed at bringing 3D gaming with a good but not the most powerful hardware, but rather pursuing high developer support through its developer functionalities. In overall, we see that those consoles that were positioned in the high user functionality & high developer disfunctionality quadrant in Figure 10 were much more likely to fail compared to those consoles having high user functionality and low developer disfunctionality.

Sixth Generation Consoles (1999 – 2005)

In this generation there were 3 main changes: First, all consoles in this generation moved on optical discs (custom-DVDs, custom-CDs, DVDs), leaving cartridges obsolete. Second, 3D gaming matured, making 2D games belonging to a small niche. Third, multiplayer gaming through internet became more established. There were 4 consoles in total in this generation. Early mover was Dreamcast, through which Sega aimed to become a strong player in the market again. Dreamcast was followed by Sony's PlayStation 2, Microsoft's Xbox, and Nintendo's Gamecube.

Dreamcast was a considerable leap from the previous generation consoles in terms of hardware at the time of its release. It offered a 200 MHz processor with 16MB of main memory, as well as a NEC PowerVRII graphics processor that was cutting edge at the time of its release. Dreamcast had a custom-CD (GD-ROM) drive, as Sega decided not to use DVD since they would be prohibitively expensive in 1999 for a console. This would later prove to be a major issue for Dreamcast due to very fast adoption of DVD, and rampant piracy due to security vulnerability. Moreover, Dreamcast was the first console to have a built-in modem for Internet and multiplayer gaming – which was not even the case for some following consoles such as Playstation 2.

Playstation 2 had 293 MHz custom processor named "Emotion Engine" and combined this with custom graphics processor named "Graphics Synthesizer". These processors are supported by

TABLE 11

Total Game Releases in each year in US for 1991-2001

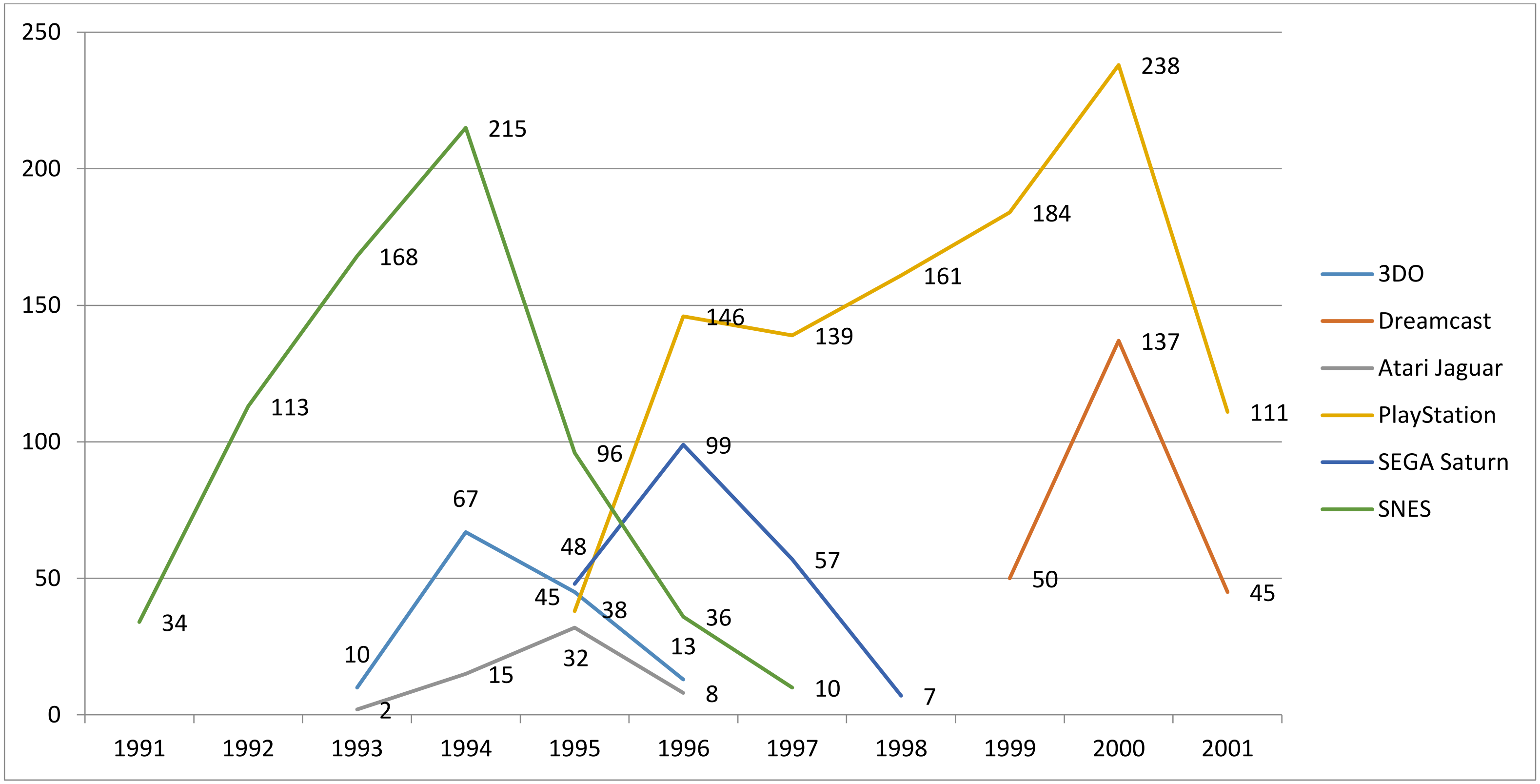


TABLE 12. Summary of Complementor Disfunctionalities, and Game Release Performance for Fifth Generation Consoles

Console	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
3DO	YES	No	YES	Games available by the first Christmas (93'): 10
				Games available in the first 12 months: 71
				Exclusive games for the console: 73
				Ported games from old generation devices for the console: 17
	Example Quotes			First-party (second-party) games: 11 (2)
	Joe Miller, Sega NPD VP on 3DO: "That was one of the reasons, frankly – and I'm probably getting into dangerous territory here – why the 3DO never fulfilled its promise, in my view. It was difficult to develop for, and it took several developmental cycles, several title cycles, for people to really get comfortable with that architecture."			Third-party games: 126
				Average quality of games (First & Second-Party): 77.85/100
				Average quality of games (Third-Party): 69.81/100
				# of hits: 6 (Critical Acclaim= 85+/100)
				# of hits: N/A (1 Million+ sales)
Jaguar	YES	YES	YES	Games available by the first Christmas (93'): 2
				Games available in the first 12 months: 17
				Exclusive games for the console: 47
				Ported games from old generation devices for the console: 14
	Example Quotes			First-party (second-party) games: 41 (33)
	David Wightman: "The Jaguar had a European soul with a Texan hat... [A]merican coders by route of the Apple II and PC had learned to go through a bios and an operation system to code, they had a tough time dropping down to binary after the luxury of APIs and libraries which they had become accustomed to. That's a core reason why very few titles came from American corporations before launch, they			Third-party games: 30
				Average quality of games (First & Second-Party): 59.91/100
				Average quality of games (Third-Party): 68.72/100
				# of hits: 2 (Critical Acclaim= 85+/100)
				# of hits: N/A (1 Million+ sales)
Saturn	YES	YES	YES	Games available by the first Christmas (93'): 48
				Games available in the first 12 months: 53
				Exclusive games for the console: 86
				Ported games from old generation devices for the console: 28
	Example Quotes			First-party (second-party) games: 64 (28)
	David Rosen, Co-founder of Sega: "Sega has tremendous engineering and technology capability. It's an interesting situation that really comes out of our coin op business. Basically, due to the coin op business we have this ability to translate and transpose the engineering know how into consumer product, consumer oriented product. Sometimes we become over-sophisticated and think anybody can			Third-party games: 149
				Average quality of games (First & Second-Party): 76.82/100
				Average quality of games (Third-Party): 71.69/100
				# of hits: 21 (Critical Acclaim= 85+/100)
				# of hits: 2 (1 Million+ sales)
Playstation	No	No	No	Games available by the first Christmas (93'): 42
				Games available in the first 12 months: 133
				Exclusive games for the console: 839
				Ported games from old generation devices for the console: 25
	Example Quotes			First-party (second-party) games: 181 (103)
	"Sega's machine...required the best coders to really get the most out of it. Meanwhile, third-party studios were getting stuck in to Playstation game production, and a string of classic titles began to emerge." (Retrogamer, 2012)			Third-party games: 961
				Average quality of games (First & Second-Party): 73.42/100
				Average quality of games (Third-Party): 68.54/100
				# of hits: 90 (Critical Acclaim= 85+/100)
				# of hits: 110 (1 Million+ sales)
Nintendo 64	YES	No	No	Games available by the first Christmas (96'): 8
				Games available in the first 12 months: 24
				Exclusive games for the console: 163
				Ported games from old generation devices for the console: 3
	Example Quotes			First-party (second-party) games: 51 (37)
	Required to rewrite part of the graphics processor microcode to get most out of the machine (Retrogamer, 2012)			Third-party games: 238
				Average quality of games (First & Second-Party): 79.9/100
				Average quality of games (Third-Party): 68.69/100
				# of hits: 41 (Critical Acclaim= 85+/100)
				# of hits: 42 (1 Million+ sales)

a math co-processor (FPU), but more importantly by two vector unit co-processors (VPU0 & VPU1) which were the heart of PS2's hardware power. In overall, Playstation 2 adopted a considerably more complex hardware than Playstation. Moreover, Playstation 2 was the first console to have a DVD. This was a deliberate strategy by Sony to push its own DVD standard, and also to sell Playstation 2 at prices close to standard DVD players – subsidizing part of the cost of Playstation 2.

Xbox was developed by Microsoft, which learned about consoles through its partnership with Sega to help creating a development environment using Windows CE for Dreamcast. Microsoft perceived Sony as a big threat for its business, and decided to enter the "battle for living rooms" by using its existing experience in the PC operating system and related developers' ecosystem. Microsoft adopted a different approach than other console producers, opting to use the PC hardware as core technology for the Xbox to court developers familiar with this technology – those that were developing already games for Windows PCs. It used a 32-bit Intel Pentium III processor at 733 MHz, combined with a NVIDIA graphics processor. Besides Playstation 2, Xbox was the other console that used DVDs as media. Xbox is the strongest hardware of the generation.

Gamecube was released a few days after Xbox in the U.S., and it was aimed to be an easy-to-develop, low-cost and graphically capable console. It was also the departure of Nintendo from cartridges, though it did not adopt DVDs, but rather custom mini DVDs that have approximately a third of the size of DVDs (1.5GB vs. 4.7GB).

Dreamcast was designed in every way that Saturn wasn't: Sega took care this time to make the console simple and easy to develop for developers. Also, Sega had invested heavily in Dreamcast development tools (Evans et al., 2006; p.133). Yet, one important point that harmed Dreamcast was the lack of a DVD player. As DVDs became more popular – thanks to Playstation 2 – Dreamcast's lack of DVD player made mainstream consumer to ignore the console. Also, due to security vulnerability, Sega custom-CDs became effectively useless, making the console able to work with standard CD-ROMS, without any security lock on the console side (Pettus, 2013). Thus, rampant piracy harmed Sega on two fronts. First, Sega lost lots of royalties that would come from game sales – which it required to survive as Dreamcast was sold below its cost. Second, game developers, having seen piracy, effectively discounted the installed base of Dreamcast.[34]

Playstation 2, on the other hand, was designed to be the cutting-edge customized gaming machine, combining DVD player functionality for users in addition to console gaming. However, the complex architecture of Playstation 2 required considerable amount of time and resource investment to utilize the hardware in its fullest. The architecture has been explained by the co-founder of prominent developer *Naughty Dog*'s Jason Rubin:

"There are three main chips that you use on the PS2 for computing potential. There's the CPU chip, which is a pretty powerful CPU. There's VU0 [Vector Unit 0] and VU1 [Vector Unit 1]… [T]he CPU of the PlayStation 2 is 100 to 150MHZ slower than the Gamecube. So the base CPU is a slower piece of hardware. However, if you only use that, that would be the equivalent of driving a 12-cylinder car and using only six of its cylinders. It's not the way you do it correctly." (IGN, 2000). This has been explained by IGN website as: "To adequately tap PlayStation 2's Vector Units is to devote your development resources entirely to the console -- to literally allocate all of your time, money and energy into getting the most out of the system. It's not easy, and it has led many developers formerly working on PlayStation 2 software to jump and run to the competition." (IGN, 2000).

Many others in the industry commented this openly. Gozo Kitao, the general manager of Konami, stated: "If you focus on making full use of all the specs, it will be very expensive and time-consuming to produce a game" (Evans et al., 2006; p. 132. However, there were two important user benefits of PS2, beyond its hardware power. First, it was backwards compatible. Given the enormous game library of Playstation 1, which consisted of over thousand games, Playstation 2 had an available library of games at the time of launch. Second, it was a DVD player with a lower cost than standalone DVD players.

Xbox on the other hand, was the most superior console of the generation when it arrived to the market. Also, it had the advantage of being very easy and familiar to develop for many PC

[34] http://kotaku.com/piracy-killed-the-dreamcast-piracy-saved-the-dreamcast-1629828642, accessed 12 February 2015. Also, note that although it has been argued that piracy led to more sales for Dreamcast, having sold the console below its cost, and had its installed base discounted by developers, did more harm than any benefit.

game developers. “[Microsoft] built the Xbox software platform around DirectX, a collection of Windows software services that were specially designed to help PC game developers deal with the diversity of user hardware, particularly the sound and graphics cards that were so important to games.” (Evans et al., 2006; p…). It has been also noted that Microsoft gave active support to developers, which “it courted… to an extent unprecedented in the video game industry” (Evans et al., 2006; p…). An additional merit of Xbox to users is its default broadband connectivity, which proved to be an important source of advantage as internet and multiplayer gaming became more established. Later versions of PS2 sold from 2004 onwards (“slimline models”) added this feature by default to compete with Xbox.

Gamecube, emphasized its easiness to develop for, to the extent that Nintendo engaged some developers in the designing process of the console.

"The N2000 [development name of Gamecube] is designed from the get-go to attract third-party developers by offering more power at a cheaper price. Nintendo's design doc for the console specifies that cost is of utmost importance, followed by space" (IGN, 1999).

"To ensure that GameCube was more developer friendly, Nintendo brought developers on board to help influence the hardware’s design. One of those developers was Martin Hollis, the director of Goldeneye 007 and Perfect Dark for the Nintendo 64" (Rogers, 2014).

Performance Implications

In this generation, there was one clear dominant player, Playstation 2. Xbox and Gamecube ended up sharing the rest of the market, while Dreamcast had a good start initially, but exited the market prematurely once the PS2 arrived. Financially troubled, Sega decided to leave the hardware market and focus on software only – Dreamcast had approximately 3.5 million sales in US by the time Sega left the hardware market, far behind the 5 million sales they targeted as requirement to keep stay in the market. Dreamcast was the worst performing console in this generation. PS2 in total reached approximately 47 million sales in US, starting from only 1.5 million sales in Christmas 2000, and quickly ramping up to 10 million cumulative sales by the end of Christmas 2001. Xbox had a quite successful early launch, selling 1.5 million units in 3 months (Orland, 2013). Still, it only ended up selling 15.7 million units in US and Canada combined by the end of 2005 (Microsoft Corporation, 2006). Gamecube sold 2.2 million in US and Canada combined until third quarter of 2002, and had total sales of approximately 13 million for the same region (Nintendo Corporation, 2014). These performance figures were a bit different in terms of game quantity and quality, perhaps also because of the unusual victory of PS2 and premature exit of Dreamcast. For example, due to development difficulties of PS2, it had only 44 titles by its first Christmas (2000), while Dreamcast had 51 titles in its first Christmas (1999). Dreamcast also had unusual number of hits for a failing console: it had 38 critically acclaimed hits just in 16 months of life. However in the long-term, game performance data is congruent with the sales of consoles: Playstation 2 had over thousand third-party game releases, and around 150 and 160 hits in terms of critical acclaim and sales respectively. Gamecube had only around 450 third party game releases and 57 and 27 hits in critical acclaim and sales. Xbox had 747 third party game releases and 111 and 20 hits in critical acclaim and sales. Table 13 lists information on developer disfunctionalities and game release performance.

Why did Playstation 2 succeed (to the extent of dominating the market)? Playstation 2 was the most technically complex console in this generation. However, it was able to "buy time" that was required for developers to get familiar with the console. It was due to combination of unique factors that allowed Sony to manage high developer disfunctionality, while offering high user functionality to build momentum quickly. There were two major factors that allowed this risky strategy to pay off. First, Sony already had the incumbent platform, as Playstation already held half of the console market when Playstation 2 was released. Sony's existing Playstation user and developer base gave it a great advantage. However, this alone would not guarantee success, as proved by Nintendo's demise in the earlier generations, and as Sony itself would experience with Playstation 3 in the Seventh Generation. Besides backwards compatibility and DVD functionality, there was another equally important factor in Playstation 2's success. After Dreamcast left the market early in 2001, Playstation 2 was the only sixth generation console in the market without any competition until the Christmas of 2001: the only major competitor, PlayStation, was also owned by Sony. In that period, PS2 was already able to reach high number of user base that would support what *Naughty Dog*'s Jason Rubin said earlier in 2000:

"My point is, if the PlayStation 2 is going to sell as many hardware units as the PlayStation 1 sold, then I don't care if I have to pierce my nails with pins to get it to work, I'm going to do it because that's where the money is. And that's the attitude we go into every game with" (IGN, 2000).

Why did Xbox and Gamecube (to a lesser extent) have some success, and why did Dreamcast fail? Xbox and Gamecube were able to hold on the market even in the face of PS2's dominance due to their offering of high levels of user functionality, with low levels of developer disfunctionalities. This was even sharper in the case of Xbox, which offered both higher level of user functionality through its technical power, and was easiest to develop for in this generation. Indeed, it performed better than Gamecube, yet it was still dominated by PS2, as PS2 already had several millions of user base by the time of release of Xbox (Christmas of 2001). Failure of Dreamcast was due to a combination of unique factors, which permeated this generation.[35] Dreamcast was able to gather many developers early on due to its easiness of development, and stronger hardware compared to older generation consoles early on. However, Sega no longer had financial resources to support a head-to-head competition when PS2 loomed ahead, and although it tried to reach an installed base large enough to gain momentum, it was not able to do so for two main reasons: (1) Dreamcast lacked DVD, which drove majority of the early PS2 adoption, and it eventually made the system vulnerable to piracy, cutting significantly the royalties required for Sega to compete, and game sales for developers; (2) Dreamcast entered too early the generation, which caused it to be underpowered. In sum, this generation shows idiosyncratic events whereby PlayStation 2, a console presenting lots of challenges for developers, was able to dominate the market.

In sum, this generation was an exceptional period in the industry, where Dreamcast left the market early, and allowed PS2 to dominate it due to its already strong PS1 incumbency and no competition for almost a year. In such a period, PS2's developer disfunctionalities delayed game

[35] http://www.cnet.com/news/sega-dreamcast-gamings-most-magnificent-failure-video/, accessed 16 February 2015
http://www.polygon.com/2013/8/7/4599588/why-did-the-dreamcast-fail-segas-marketing-veteran-looks-back, accessed 16 February 2015
http://venturebeat.com/community/2009/09/11/qaa-former-sega-president-on-dreamcasts-failure-pranks-against-sony-his-ouster/, accessed 16 February 2015

TABLE 13

Summary of Complementor Disfunctionalities, and Game Release Performance for Sixth Generation Consoles

Console	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
Dreamcast	**No**	**No**	**No**	Games available by the first Christmas (99'): 51
				Games available in the first 12 months: 131
				Exclusive games for the console: 155
				Ported games from old generation devices for the console: 50
	Example Quotes			First-party (second-party) games: 51 (16)
	"Sadly it was just released at an odd time in the history of console. It came out sort of between generations and while it was ahead of one, it was way behind the next." (Aune, 2000)			Third-party games: 193
				Average quality of games (First & Second-Party): 78.78/100
				Average quality of games (Third-Party): 67.42/100
				# of hits: 38 (Critical Acclaim= 85+/100)
				# of hits:7 (1 Million+ sales)

Console	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
PS2	**YES**	**YES**	**No**	Games available by the first Christmas (2000'): 44
				Games available in the first 12 months: 155
				Exclusive games for the console: 622
				Ported games from old generation devices for the console: 51
	Example Quotes			First-party (second-party) games: 114 (44)
	"The development of Playstation 2 applications is considered highly complicated, largely due to the sophisticated system architecture, the heavy assembly-level development and the lack of hardware functionality. We hoped to remove all difficulties related to the Playstation 2 to make developers' lives easier"			Third-party games: 1375
				Average quality of games (First & Second-Party): 73.96/100
				Average quality of games (Third-Party): 69.73/100
				# of hits: 142 (Critical Acclaim= 85+/100)
				# of hits:161 (1 Million+ sales)

Console	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
Xbox	**No**	**No**	**No**	Games available by the first Christmas (2002'): 37
				Games available in the first 12 months: 158
				Exclusive games for the console: 208
				Ported games from old generation devices for the console: 21
	Example Quotes			First-party (second-party) games: 50 (37)
	"PlayStation 2 and GameCube did not come with built-in network connections but could be connected through either a 56K modem or an Ethernet adapter. By contrast, Microsoft chose to integrate a broadband-only connector to simplify the life of online game developers, who did not program for slower forms of Internet access. Of course, this was a gamble on the growing penetration of broadband connectivity,			Third-party games: 747
				Average quality of games (First & Second-Party): 76.29/100
				Average quality of games (Third-Party): 70.2/100
				# of hits: 111 (Critical Acclaim= 85+/100)
				# of hits: 20 (1 Million+ sales)

Console	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
Gamcube	**No**	**No**	**No**	Games available by the first Christmas (2001'): 20
				Games available in the first 12 months: 128
				Exclusive games for the console: 121
				Ported games from old generation devices for the console: 19
	Example Quotes			First-party (second-party) games: 48 (29)
	(Comparing Gamecube with PS2): " "The PS2 undoubtedly can be a great machine if used right. The Vector Units especially have some potential. We have used the N64 Vector Unit probably more than anybody else out there. Battle for Naboo and Indiana Jones use the N64 Vector Unit for almost unlimited dynamic lights, we did a complete particle system on it,			Third-party games: 456
				Average quality of games (First & Second-Party): 76.1/100
				Average quality of games (Third-Party): 70.23/100
				# of hits: 57 (Critical Acclaim= 85+/100)
				# of hits: 27 (1 Million+ sales)

development, but, being the only platform in the sector, eventually developers commit to invest in learning how to work with it. This left Xbox and Gamecube with residual demand.

Seventh Generation Consoles (2005 – 2012)

In this recent generation of consoles, most important difference was that there were no new entrants to the market. Microsoft wanted to challenge Sony, so it moved fast with its release of Xbox 360, which was the first entrant to this generation. Actually, Xbox 360's processor, produced jointly with IBM, was based on the research alliance Sony had with IBM for Playstation 3. Though these two machines had their processor from the same research line in IBM, they adopted quite different technological architectures. Xbox 360 was able to come to market faster due to its less complicated hardware, while Playstation 3's CPU research took some more time, and it arrived almost a year later than Xbox 360. Nintendo was the last entrant with its console, Wii, following Playstation 3 with a month. Two technically advanced consoles of this generation, Xbox 360 and Playstation 3, adopted full support for "high definition" resolutions, while all three consoles embraced full internet connectivity for multiplayer gaming, social community, and digital game store.

Xbox 360 followed Xbox to a great extent, in combining both user functionality and easing the work of developers as much as possible. However, this time Microsoft used "Xenon" processors, which are a three-core variant of IBM's PowerPC line, instead of PC processors of Intel. This is a simplified version of the same processor used in PS3 later (that variant had seven-cores). Xbox 360 used DVD player, as in Xbox. In terms of hardware power, Xbox 360 was superior than Nintendo Wii, but behind PS3. In terms of developer disfunctionalities, Xbox 360 was more complex, but also more capable than Wii, but easier to develop for than PS3.

PS3 was a high-end console that was based on custom chips focused on delivering high performance, and it also introduced the cutting edge optical media for the first time to the market: Blu-ray. However, PS3 resulted the most complex console in the market as it had an advanced processor that requires special coding techniques to get the most out of the hardware.

Nintendo followed perhaps the most interesting strategy. Wii was not designed to compete with the other two consoles in terms of technical power. It had the simplest architecture out of the three consoles, relying on a single core PowerPC based processor, based on an iteration of Gamecube design. It also didn't feature HD graphics, unlike the two other consoles of this generation. Also, Wii used custom Wii Optical Discs, and it was not able to play DVDs officially (thought later homebrew hacks enabled it to do so). As put forward by famous developer of Mario games, Shigeru Miyamoto:

"The consensus was that power isn't everything for a console. Too many powerful consoles can't coexist. It's like having only ferocious dinosaurs. They might fight and hasten their own extinction" (Kenji, 2007).

Xbox 360 has been praised to be as relatively easy to develop given its powerful hardware. In the early days of Xbox 360, Japanese developers expressed that the platform has a developer-friendly development environment and array of tools that also gives them flexibility in reusing programs they have previously created (Gamespot, 2005). Especially later when PS3 was out, the comparison become clearer:

"In a generation with few third-party exclusives to separate them, 360 still places ahead of PS3. ... it's about the choices Microsoft made back in the original Xbox's lifetime. The PC-like architecture meant those early EA Sports titles ran at 60fps compared to only 30 on PS3, Xbox Live meant every dedicated player had an existing friends list, and Halo meant Microsoft had the killer next-generation exclusive. And when developers demo games on PC now they do it with a 360 pad – another industry benchmark, and a critical one" (Edge, 2013).

Playstation 3 was the strongest console in the generation, having a similar but more advanced and complex version of Xbox 360's processor, and having a Blu-ray reader that allows both game play and high definition movie playing functions. It also featured a more capable main memory. Although PS3 was cutting-edge in terms of hardware, it was not so well received by developers. Gabe Newell, founder of Valve which owns the biggest digital PC game retailer, Steam, said that:

"The PS3 is a total disaster on so many levels, I think It's really clear that Sony lost track of what customers and what developers wanted... Just say, this was a horrible disaster and we're

sorry and we're going to stop selling this and stop trying to convince people to develop for it" (Bishop, 2007).

Sony has also admitted it. Perhaps ringing too similar to what Sega of America's CEO Tom Kalinske maintained about Saturn back in 1995, Kaz Hirai, back then president of Sony Computer Entertainment told that:

"We don't provide the 'easy to program for' console that [developers] want, because 'easy to program for' means that anybody will be able to take advantage of pretty much what the hardware can do, so then the question is what do you do for the rest of the nine-and-a-half years? So it's a kind of - I wouldn't say a double-edged sword - but it's hard to program for, and a lot of people see the negatives of it, but if you flip that around, it means the hardware has a lot more to offer" (Purchese, 2009).

Wii was the unexpected console. Initially many developers thought an underpowered console would stand no chance in the market. However, this view has quickly changed. [36] Developers have praised easiness of development for Wii , and also the fact that Wii games were far less resource consuming, as they were more similar to previous generation games.

"One of the things we like about the Wii is that development costs are nowhere near what they are on the PS3 and Xbox 360. (...) The Wii wasn't a whole new programming environment. So we had a lot of tools and tech that work in that environment" (Sinclair, 2006; Anderson et al., 2014, p.153).

However, towards the end of the generation, developers had considered Wii underpowered, and many turned their attention to Xbox 360 and PS3, as the statement made by Call of Duty series' developer, Infinity Ward's community manager Robert Bowling, made clear:

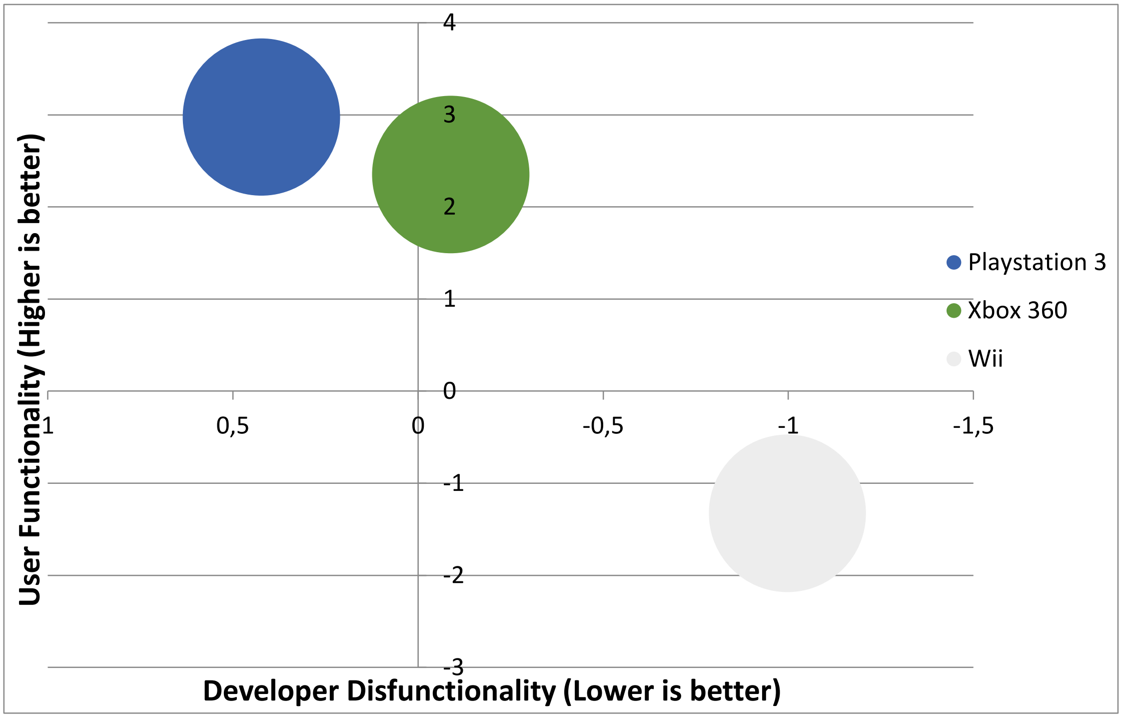
"If we felt like we could deliver the cinematic experience we were going for on other platforms, then we would gladly move to that platform.. [R]ight now, we don't think the Wii can deliver the exact experience that we're doing. We like to be very equal across all platforms, and if it's not equal then we won't do it" (McFerran, 2009).

[36] "The happy story is the Wii," he [Gabe Newell] said. "I'm betting that by Christmas of next year, the Wii has a larger installed base than the 360. Other people think I'm crazy." (Bishop, 2007)

We have mapped user and developer (dis)functionalities for all consoles of this generation in Figure 11.

FIGURE 11

Dimensions of Technology: Technological Superiority as User Benefits and Developer Costs for 7th Generation Consoles



Performance Implications

Latest entrant Wii proved to be a runaway success, dominating the market by mid-2009. In April 2009, Nintendo Wii had 46.58% market share, as compared to 35.49% market share of Xbox 360, and 17.93% market share of Playstation 3 in the U.S.[37] Later on, as Nintendo Wii adoption slowed down, Xbox 360 gained market share. At the end of 2011, when Nintendo released Wii U (and focused its efforts to this new console) to upgrade the older hardware and started the new console generation, market share of the three consoles in the US were as follows: Wii 42%, Xbox 360 36%, and PS3 22%. Game release performance shows strongly how developer disfunctionalities harmed PS3 compared to other consoles. Wii had the most games available for it by its first Christmas, 48,

[37] Source: www.vgchartz.com

while Xbox 360 had 31, and PS3 just 17. Although Wii didn't have much critically acclaimed games (31 compared to 89 of PS3 and 111 of Xbox 360), it had highest number of hits in terms of best-sellers (103 compared to 27 of PS3 and 56 of Xbox 360). It is also clear that Xbox 360 was superior in both quality and quantity of games vis-à-vis PS3 –PS3's technical superiority didn't pay off. It could be said that Nintendo Wii was the leader in this generation, and Xbox 360 became a strong contender towards the end of 2011, while PS3 remained a follower with little hope for leadership, losing its strong position after many years. Table 14 lists information on developer disfunctionalities and game release performance.

Why did Wii, and Xbox 360 succeed? Though Nintendo Wii's success has been attributed to its innovative motion-sensitive control and accompanying games more favored by a growing casual gaming segment in the industry, "… the remote cannot fully explain Nintendo Wii's dominance, because for a long time most of the games developed for the Wii used the traditional joystick technology" (Anderson, Parker, and Tan, 2014: 153). Wii's success can be attributed to the relative ease of game development by developers on two fronts: First, it was essentially a modified previous generation console that was perhaps only double the power of previous generation consoles, which allowed developers to directly apply their learning accrued in the previous generation (Anderson et al., 2014). Second, due to having less hardware demanding games, it allowed developers to have much cheaper game development costs in otherwise an industry having immensely rising game development costs.

"So those costs--and again, I hate these broad generalizations--but they could be as little as a third of the high-end next-gen titles... Maybe the range is a quarter to a half" (Sinclair, 2006).

Xbox 360 was successful because it offered relatively low developer disfunctionalities while offering user benefits, especially compared to its close competitor PS3. For example, Activision's CEO, Bobby Kotick said:

"It's expensive to develop for the console [PS3], and the Wii and the Xbox are just selling better. Games generate a better return on invested capital on the Xbox than on the PlayStation" (Walton, 2009).

TABLE 14

Summary of Complementor Disfunctionalities, and Game Release Performance for Seventh Generation Consoles

	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
Xbox 360	**No**	**No**	**No**	Games available by the first Christmas (2005'): 31
				Games available in the first 12 months: 121
				Exclusive games for the console: 584
				Ported games from old generation devices for the console: 227
	Example Quotes			First-party (second-party) games: 124 (83)
	Xbox tools and support were always excellent, and the TCRs and supplementary FTCs [functional test cases - Ed.] were much easier to read, understand, implement, and test. They were also much more lenient about what was acceptable in a lot check, or making exceptions when it made sense to do so. I've heard Sony has greatly improved their tools support for development and testing, though I believe			Third-party games: 1187
				Average quality of games (First & Second-Party): 73.66/100
				Average quality of games (Third-Party): 71.10/100
				# of hits: 111 (Critical Acclaim= 85+/100)
				# of hits: 56 (1 Million+ sales)
PS3	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
	YES	**YES**	**YES**	Games available by the first Christmas (2006'): 17
				Games available in the first 12 months: 96
				Exclusive games for the console: 161
				Ported games from old generation devices for the console: 132
	Example Quotes			First-party (second-party) games: 100 (64)
	"This is how sad the industry is right now. If Sony thought of a way that their architecture designers could somehow add even more power for less money, but made programming a misery - actually made you just want to kill yourself - they would do it. (Gibson, 2007)			Third-party games: 675
				Average quality of games (First & Second-Party): 78.11/100
				Average quality of games (Third-Party): 72.84/100
				# of hits: 89 (Critical Acclaim= 85+/100)
				# of hits: 27 (1 Million+ sales)
Wii	Time Compression Diseconomies	Resource Allocation Problems	Lock-in Problems	Game Release Performance
	No	**No**	**No**	Games available by the first Christmas (2006'): 48
				Games available in the first 12 months: 217
				Exclusive games for the console: 353
				Ported games from old generation devices for the console: 232
	Example Quotes			First-party (second-party) games: 102 (41)
				Third-party games: 653
				Average quality of games (First & Second-Party): 75.7/100
				Average quality of games (Third-Party): 64.64/100
				# of hits: 31 (Critical Acclaim= 85+/100)
				# of hits: 103 (1 Million+ sales)

Actually development for PS3 initially proved so difficult that even with its superior hardware, PS3 games that were also developed for Xbox 360 mostly underperformed compared to their Xbox 360 counterparts (especially at the initial release of PS3 where problems are most significant).

"You'd think that the PS3 versions would be exactly the same or slightly superior to the Xbox 360 versions, since many of these games appeared on the 360 months ago, but it seems like developers didn't use the extra time to polish up the graphics for the PS3. We found that the Xbox 360 actually had better graphics in the majority of the games we compared" (Shah and Yu, 2006).

Why did PS3 fail? PS3 failed, because developer disfunctionalities at the early stage of its release caused it to lose important momentum. In developing PS4 (not included in this study), Mark Cerny, the head architect of the system attributed the problems Sony experienced prior to the release of PS3 to the complexity of the processors' and programming environment, which made it difficult for developers to perform "the most basic tasks" (Scammell, 2013). Development tools support for PS3 was also limited.

"The development environment was in a very primitive state. The first party teams were having a difficult time of it but the third party teams, without the luxury of being able to focus just on PS3, and without the benefit of our (Sony's) head start, were having an even more troubling time. The teams that I'd worked with, first party, needed basically a whole year to create usable graphic engines. The sky high expectations for game titles could only be met with clever use of the SPUs, but both the unique nature of the Cell and the primitive state of the development environment meant that game creation on PlayStation 3 was more time consuming than any previous product" (Hurley, 2013).

In sum, results from this generation were quite similar to the 5th generation. Back then, Sony won the market by combining low levels of developer disfunctionalities with high levels of user functionalities. Yet, this time Playstation 3 was the "new Saturn", and Sony eventually lost its lead in the market after two generations due to developers' learning problems and relatively less willingness to commit resources.

Summary of study's findings

The analysis of the different platform technology generations in the video game industry presented above reveals interplay between technological (dis)functionalities to users and complementors that critically affects the formation and growth of an ecosystem around the new-generation platform technology. As described above, the fourth generation of gaming consoles showed a similar level of complementor-related (dis)functionalities; the platforms that ended up gaining dominance were indeed those with superior technology, i.e., those offering greater technological functionalities to users. Consistent with traditional conceptualization of technological superiority, these platforms were offering users greater value and were been adopted. Since developers faced similar technological environments (and thus innovation challenges), they just selected the platforms that were gaining (or expected to gain) increasing user base. However, the following generations showed high variance in terms of technological (dis)functionalities, both on the user and complementor side. Platforms that offered limited functionalities on both sides, such as Philips CD-i, were clearly of limited value to both users and complementors. These platforms hardly gained any ground. However, also platforms offering great levels of functionalities to users like Sega Saturn and Playstation 3 eventually failed to gain market dominance vis-à-vis competing platforms with similar or lower levels of user-related (dis)functionalities that provided greater benefits or lower dis-functionalities to complementors – e.g., Nintendo Wii, PlayStation.

Essentially, this suggests that the window of opportunity for the leapfrogging platform could be shorter than expected. New generation consoles, even if of superior technology, offer not much value to users unless there are games developed for it to play. It has been a common problem that games developed for new machines simply didn't take advantages of the new superior technical features, as developers didn't invest much to harness the technological power of the new console. This issue is exacerbated by the installed base of old generation consoles, with developers preferring to release games for this installed base even after console user base is not increasing (Clements and Ohashi, 2005).

In light of these findings, technological superiority as traditionally conceptualized, instead of being an enabler, represented, in fact, an important potential obstacle to ecosystem formation and growth. This highlights a paradoxical property of technological superiority (as traditionally conceptualized) when a radical innovation is undertaken to leapfrog the incumbent. While it provides more benefits to users, it also creates a gap in the knowledge required for the complementors to support the platform. The greater the technological superiority, the greater the gap in this knowledge, and the required learning investments. This paradox essentially limits the value of the technology in system contexts, contrary to what has been argued in the literature for more traditional contexts.

This paradox is essentially determined by three main problems associated with technological superiority: (i) time compression diseconomies, (ii) resource allocation problems, and (iii) lock-in problems. Time compression diseconomies will be present due to impossibility of compressing learning in a short time period even with an increased allocation of resources (Dierickx and Cool, 1989). Resource allocation problems will be present due to limited current value of the new platform for the complementor, inducing the complementor to allocate second-tier resources to the platform-specific complements' development. Lock-in problems will be present due to market uncertainty – complementors will be unsure if it pays off to invest and learn for this new platform as much of this investment would be lost in case the platform does not turn to be popular in the market.

DISCUSSION

We have started this article by pointing out the recognized determinant role played by new, superior technology in shaping competition toward a dominant technological platform, as acknowledged by several studies in the literature. It has been also recognized that this effect is more pronounced in networked markets because of the increasing returns to scale ensuing from network effects dynamics. Notwithstanding these benefits, superior technology may not always become the dominant platform. Scholars have attributed this to excess inertia (Katz & Shapiro 1994), and lack of a sufficient user base or complements (Schilling 2002; Suarez 2004). Also, even when users and complementors embrace early on the new, superior technology, this may fail to become the industry standard. However, why users, and complementors, would choose an "inferior" technology remains a puzzle, and, surprisingly, an under-theorized, and overlooked phenomenon. Only a handful of studies have explored the issue, pointing to industry specificities or peculiar, idiosyncratic events (e.g., Arthur 1989; Rosenbloom and Cusumano, 1987).

We thus raised such question as the core of our inquiry. Specifically: Why do new, technologically superior platforms fail, despite gaining early momentum? Our objective was to gain insights on the underlying factors magnifying (constraining) the benefits (costs) of introducing a new, superior technology. Our analysis of US Video Game Industry revealed that, technological superiority, which is used by challengers in platform competition, has a paradoxical property. As much as it drives early user adoption by offering direct benefits to users (greater technological functionalities), it entails shadow costs for complementors in terms of learning, opportunity costs, and investments. This limited the emergence and growth of a thriving ecosystem around the new technology.

However, this does not mean that technological superiority should not be pursued. To the contrary, examples of successful platforms in our research context show that, when properly managing the inherent paradox that technology superiority entails, it creates opportunities for value creation. We have gone further in our analysis to gain insights on how do firms manage this paradox of technological superiority, an issue we briefly turn now.

Managing the Technological Superiority Paradox: Vertical Integration and Co-opetition

We have so far mentioned difficulties faced by complementors when deciding to join and support a new platform technology. How were console owners then able to attract developers early on in the new technology life cycle? Almost every platform did by producing itself parts of the needed games. Most platform owners in the videogame industry had an extensive in-house video game production. These complementary products released by the console owner itself were used to sustain the console through its life, but its primary purpose was to build the best games possible to showcase the power of the console early on in the new technology life cycle, and gain an initial lead in user base. Joe Miller, who was the Senior Vice President of Product Development of Sega in the 90s answered in an interview that: “First party software is meant to accelerate the growth of an installed base so third parties can jump on the bandwagon and quickly develop great titles for the hardware and generate higher margin revenue” (Horowitz, 2013). This initial user base will then serve to attract developers, and induce them to invest in learning to develop games for new consoles. Recent research also confirms the value of vertical integration in the form of in house development for attracting users to platforms (Lee, 2013).

Vertical integration in the complementary products segment, however, also entails its own issues. Objectively, it would be an ideal situation where platform owner supplies complementary products to the platform to gain a head-start, and also shares the in-house knowledge of complementary product development for the new console with external complementors. However, incentive and co-opetition problems brought by vertical integration in complementary products is a critical issue for firms sponsoring platform technologies (Gawer and Henderson, 2007). In the video game industry, platform owners were also additionally tempted to produce strong complements as the business model is based on selling the console below or at marginal cost and getting royalties for each video game sold from third party developers.[38] In the case of in house development, the firm gets 100 percent of the profit, which tempts platform owners even more to compete with their complementors. It has been widely noted that, Nintendo and Sega were reluctant to provide their knowledge through the history of the industry, until Sony beat them with Playstation through the strategy of providing its development knowledge extensively to complementors (Evans, Hagiu and Schmalansee, 2006). Along these lines, it has been argued that, "the software development kits (SDKs) for Sega CD were late in arriving from Japan, which was one of the major contributing factors towards the lack of a good software base" (Pettus, 2013, p.282). Providing a level field for both in house and external complementors is important in attracting complements (Gawer and Henderson, 2007), and failure to do so may do more harm than benefits.

Supporting Complementors: Thriving from Vertical Integration

Governance of multiplicity of factors is critical in reaching platform success (Boudreau & Hagiu, 2010), and video game industry is no different in this regard. Vertical integration into complements could be a source of advantage in fact in managing complementors since the platform can use insights gained from developing games for the new technology, and transfer this knowledge to external complementors. This would reduce their learning, hence switching costs, and increase

[38] It is important to note that challenging this business model is not useful either. For example, 3DO failed despite its strong external developer support with 3DO's below industry royalties as console was too expensive.

their ability to produce better quality games. Our reading of the history shows that those consoles that were able to successfully make the technological leapfrogging were the ones that have combined vertical integration to build the user base, while providing a level play field between complementors, echoing findings of Gawer and Henderson (2007). While technological superiority of Sony's Playstation was highly debated, its success has been attributed to software development tools (Evans et al., 2006). These development tools include graphical libraries, sound libraries and API's that ease programming for the platform greatly. By reducing the challenges faced by complementors, Sony was able to create much more value to users, and sustain support from external developers. Interestingly, among major competitors, Sony had the least extent of in house video game development – which intrinsically supports our idea in the above discussion.

Finding the Right Balance in Technological Superiority

On the long run, technological superiority may become essential. Although we argued that challenging with very advanced technology will have liabilities, so do having not enough superiority in the long run. In console industry, developers will generally favor consoles that have superior technical capabilities (graphical and processing power, memory and the like). For example, on the 128-bit console generation, Sega's Dreamcast was easier to develop games for compared to Sony's Playstation 2 (PS2). PS2's game development difficulties were attributed to "Emotion Engine" chip of the console, which was technological state of art in the generation until Xbox's late arrival. Early on, Sega hoped that it could survive as game development for PS2 delayed, while there was constant game release for Dreamcast. In fact, Dreamcast that released more than a year earlier, served as an "interim" system where developers learned how to code in the next generation technology, and developers hopped on to the later entrant PS2 when it became more promising (Pettus, 2013). This shows that technological superiority is a liability at the beginning of a new generation, while it becomes an advantage through the course of technological life cycle if it is able to sustain its momentum through network effects. Indeed, those many consoles that lead the user base by pioneering a new generation such as Dreamcast become stepping stones for later entrants like PS2, while those consoles that were superior right away in pioneering the new generation were simply not able to attract enough developers due to additional difficulties brought by technological superiority (such as Atari Jaguar).

CONCLUSION

In this paper, we have adopted an ecosystem view on superior platform technology, considering both users and complementors, and have highlighted an important paradox of technological superiority: it creates functional value for users that could lead to initial momentum, but it also puts more burden on complementors as the technological gap increases compared to existing platforms. This makes the new platform less easy and more expensive to switch to and support by complementors, therefore reducing the amount and quality of complements provided to a platform. In particular, impediments in the form of time compression diseconomies, resource allocation problems and switching costs for complementors negatively affect the ability of a technological superior new platform to obtain complements at the rate and quality needed to support the initial market momentum. This in turn would generate unfavorable expectations, and eventually lead to the failure of the platform.

Platforms would need to take an active stance to manage the ecosystem and alleviate these problems. In our discussion, we have provided several solutions to manage these issues, such as vertical integration, supporting complementors, and having the right balance in technological superiority and complementor ease of support. Yet, as we have argued, platforms should also be aware of the second order tradeoffs that these solutions entail – such as co-opetition with other complementors due to vertical integration.

By focusing on platform failures instead of successes, and adopting an ecosystem perspective, we have been able to highlight a set of dilemmas firms sponsoring new platform technologies face when trying to create more value for users, and identified the possible ways to manage them. We hope other studies may build upon these insights to enrich the analysis and understanding of this superior technology paradox.

CHAPTER 4 [39]

ENTRANT AND INCUMBENT IMITATORS: NICHE DYNAMICS AND PERFORMANCE OUTCOMES FOLLOWING A TRAILBLAZER PRODUCT

ABSTRACT

Recent research has increasingly recognized the importance of disaggregating industries into segments to better explain their evolution in terms of demand, entry, as well as incumbent and entrant competition. We argue that these dynamics in market segments depend to an important extent to trailblazer products. We propose that trailblazers will lead to an increase in segment demand and product entry, but only entrants will benefit from increased demand following the release of a trailblazer product. Incumbents are better competitors in their segments, but possess less ability and willingness to imitate trailblazer products. We test our ideas using the sample of all commercially released games for fifth-generation and sixth-generation video game consoles in US and find support for our hypotheses.

[39] This chapter is the result of joint work with Tobias Kretschmer.

"*We were inspired to create Warcraft after playing (and replaying and replaying) a game called Dune 2, by Westwood Studios. Dune 2 was arguably the first modern real-time strategy (RTS) game; with a scrolling world map, real-time unit construction and movement, and individual unit combat.*"

Patrick Wyatt, Programmer of Warcraft: Orcs and Humans (Kotaku, 2012)

INTRODUCTION

What happens following the release of a trailblazer product to a market segment? What is the role of such products for incumbent and entrant dynamics? Heterogeneity within industry structures is a central issue in management research. Early strategy literature has recognized the importance of different segments within an industry to explain performance differences between firms (Porter, 1980; McGee and Thomas, 1986). On the other hand, literature on industry evolution explains broad dynamics between incumbents and entrants (Gort and Klepper, 1982; Klepper, 1996; 1997), but it has historically focused on homogeneous product markets. Recent research in industry evolution, however, followed the wisdom in strategy research, and disaggregated industries into segments (Klepper and Thompson, 2006; de Figueiredo and Kyle, 2006), and firms into individual products (Eggers, 2012; Barroso, Giarratana, Reis, and Sorenson, 2014). However, our understanding of *evolution* of the segmented industries is still limited, with only a few studies exploring it (de Figueiredo and Silverman, 2007; Argyres, Bigelow, and Nickerson, 2015)[40].

Moreover, recent research has highlighted the key role played by product innovations in the evolution of industries as well as segments. Historically, industry evolution predicts an initial slow period of growth in the sales, followed by a sharp increase with entries, creating the "sales takeoff" (Rogers, 1995; Klepper, 1997), presumably caused by supply side factors (i.e., decrease in prices). Agarwal and Bayus (2002) found in multiple industries that firm entry is a driver of "sales takeoff" primarily because of demand side factors, not supply. They argue that as firms enter to an industry, they introduce new products improving on earlier ones, resulting in higher quality. Higher quality results in a shift of the demand curve, which drivers the sales takeoff. Relatedly, Barroso et al. (2014) have found that demand for different segments of television series depends endogenously

[40] Although organizational ecology literature studied density dependence in niches within a population, this is primarily viewed through the lens of legitimation and competition (de Figueiredo and Silverman, 2007).

on the history of products offered in the segment earlier. Similar past offerings in segment reduces demand as audience loses its interest for the segment with each offering, and this results in a decrease of performance for future products in the segment.

Though these recent research has contributed substantially to our understanding of evolution of segmented industries, they have at least one key limitation: by considering each product innovation as equal, they miss important variation in impact these products have on their industry segments. This study considers "trailblazer" products, which themselves are of exceptionally high quality, and also has much higher impact in the segment they belong to[41]. Our focus on trailblazer products is similar to recent study by Argyres, et al. (2015), which shown that major shifts in industry dynamics and competition occur upon the introduction of pioneering new product designs for which demand surges unexpectedly ("innovation shock").

We are combining evolution of market segments with the critical importance of trailblazing product innovations in driving evolution, and advance literature on both fronts. First, we extend the literature by showing that demand for segments are built endogenously through release of trailblazer product innovations. Past literature has not provided a particular endogenous source which surges segment demand in the first place.[42] Scholars either considered a particular exogenous change (e.g., technological) driving this demand (Swaminathan, 1998), or changing supply curves due to the entrance of a very large firm in the market segment (de Figueiredo and Silverman, 2007), or endogeneously determined demand due to intensity of product offerings in the past (Barroso et al., 2014). We contribute by identifying which specific products build demand in a segment, and cause following entry, imitation, and competition dynamics.

Second, by focusing on segment level dynamics consequent to trailblazer product innovations, we bring a new light on the incumbent and entrant dynamics. We show that entrants

[41] Our understanding of trailblazer products are not very different than "superstar" products, which refers to products that enjoy disproportionately large benefits due to their qualities (Rosen, 1981). However, we chose trailblazer as the term, as we are focused more on their effects on the evolution of segments for followers (hence, trailblazing), rather than their own performance in the market.

[42] Although it could be argued that innovation shocks in Argyres et al. (2015) is an example, that study is interested with one particular demand shock in the industry that creates the shift to move to the "mature" stage of competition. Instead, we are focusing on continuously identifying trailblazing products across the time for market segments within the industry.

in a segment disproportionately benefit through their entry by imitating a trailblazer product innovation, while incumbents are unable to benefit by imitating trailblazer products, but have better capabilities for the segment overall. Incumbent and entrant dynamics is a key interest to the industry evolution literature, with earlier studies based on homogeneous product markets highlighting incumbency and first-mover advantages through increasing returns on scale (Klepper, 1996; Klepper, 1997). More recent studiesrecognized the segmented structure of markets, but have provided limited explanation if incumbents or entrants perform better within a market segment. Scholars have either provided a similar version of scale economies argument for multiple connected segments (Buenstorf and Klepper, 2010), or considered an exogenous technological event that disproportionately benefits members of one segment compared to other segments (Bhaskarabhatla and Klepper, 2014). Besides these arguments, de Figueiredo and Silverman (2007) argue that "fringe" entrants following a dominant firm perform better than "fringe" incumbents in a segment, but their argument is based on cost competition, rather than capability and imitation. Last, Barroso et al. (2014) find that products in saturated segments perform worse, but have no specific argument on performance differences between incumbents and entrants. We argue and show an explanation of when entrants to market segments can benefit from entry compared to incumbents in these segments.

To test our ideas, we estimate market segment demand, product entry, and product performance following the arrival of trailblazer product innovation to a market segment in the US Video Game Industry for fifth-generation and sixth-generation consoles. Because it is a segmented industry with lots of emphasis on trailblazer product innovations, it offers an excellent setting for exploring our ideas. We find empirical support for most of our theoretical predictions. In particular, we show that trailblazer product innovations indeed increase demand in the segment, but this increased demand only benefits to entrants to the market segment, which is due to succesful imitation[43] of product features by these entrants' products. Although this study does not explore in detail what characteristics of the products in a market segment change following a trailblazer

[43] In markets where products are observable and appropriability is limited (e.g., patenting is not as strong and effective as in Pharmaceuticals), imitation is considered as a common move in the industry evolution literature (Klepper, 1996; Klepper, 1997). Process innovations on the other hand, are hardly observable and imitable.

product innovation, we hope it will encourage a finer-grained work to understand segment level dynamics better. More broadly, we hope this study will further encourage studies at the finer-levels of analysis in an industry to extend our knowledge on key strategy issues such as incumbent and entrant competition.

THEORETICAL DEVELOPMENT AND FRAMEWORK

Preliminaries: Trailblazer Products, Video Game Industry, and Summary of Theory

We define trailblazers similar to superstars, which refers to individuals or products that gain disproportionately large benefits for their superior abilities or skills (Rosen, 1981). Trailblazers command high benefits due to scarcity of high quality or abilities, and they display increasing returns to quality (Cox and Kleiman, 2000). To give an example, think about Olympic sprint races. A little difference in finishing races consistently faster could make a huge difference. Differences between top athletes are measured less than a second, but only the top winner dominates the field (e.g., Usain Bolt).

Trailblazer industries are more common than it is usually thought. They range from the market for textbooks, where a few textbooks gets most of the market, to movie industry where top performing movie makes order of magnitude box office revenues compared to other movies. Commonly, this also includes individuals in such industries, such as actresses and actors in the movie industry – only few of them earn most of the money in the industry.

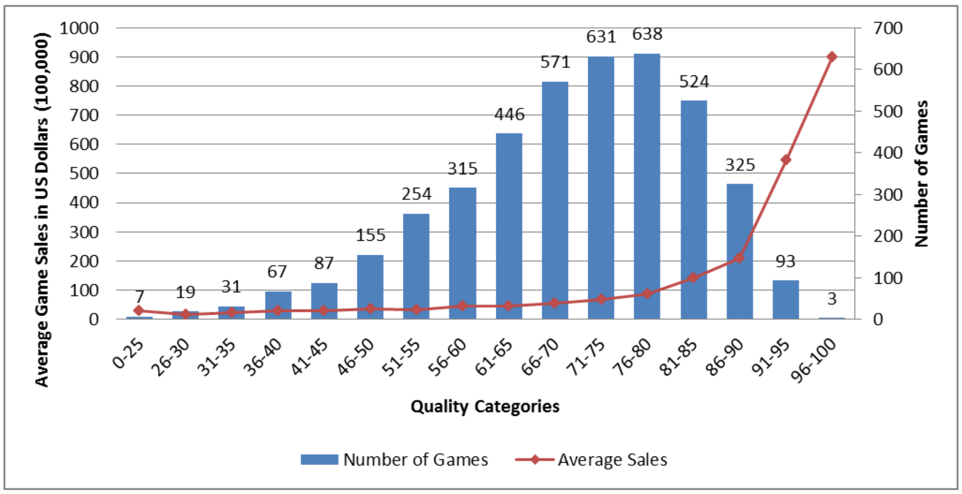
Video game industry exhibits trailblazer industry qualities (Binken and Stremersch, 2009). Each year, only a few games make most of the profit, and the availability of high quality games is scarce. Moreover, there is a monotonic relationship between quality and average sales of a game. In Figure 12, we show the distribution of quality and average revenues for games released for 5th and 6th generation video game consoles. If we categorize games according to their quality score, number of game releases in very high quality categories are rare (Quality >90), whereas average sales of a game increases exponentially as quality increases from 90 onwards[44]. As Binken and Stremersch (2009) argue, these attributes show a strong support for the video game industry as being a trailblazer industry.

[44] We will discuss operationalization of the quality score in the methods section.

With the trailblazer products are defined, and explained better in their individual qualities and performance, Figure 13 outlines the basic dynamic theoretical framework to explain segment level dynamics following the release of a trailblazer product to a market segment. The next subsections explore our framework in more detail, but the basic outline is as follows: following a trailblazer product, demand in a segment increases. This increased demand in the segment then attracts more

FIGURE 12

The Video Game Industry as a Trailblazer Industry

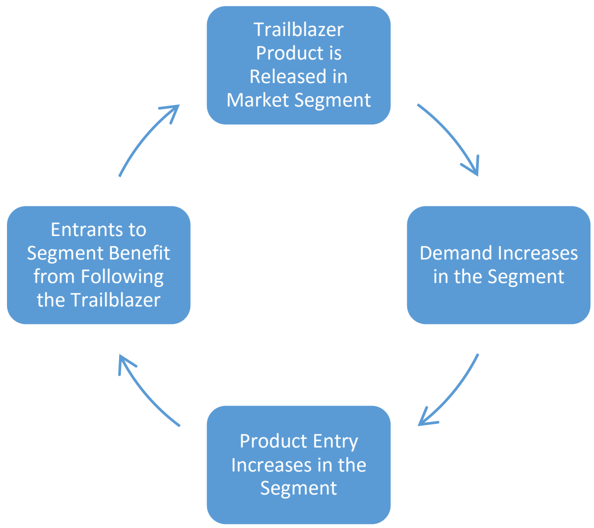


product entry to this market segment. Since there are more products competing for the demand, on average game sales do not increase. However, incumbents of the segment and entrants to the segment have different payoffs from following trailblazer product, where average revenues for entrants increase, whereas incumbents' remain unchanged. The cycle repeats itself as further trailblazer products are released in the market segment.[45]

[45] Otherwise, as more and more similar products are released in the segment over time, demand wanes due to saturation (Barroso et al., 2014).

FIGURE 13

Segment Dynamics Initiated by Trailblazer Product Innovation in a Segment



Market Segment Demand Following Trailblazer Product

What happens to the demand at the market segment level? Theoretical and empirical evidence on industry evolution indicates that entry during the early years of an industry shifts the demand curve outward (Gort and Klepper, 1982). This is due to entrants bringing crucial new innovations. Relatedly, this literature argues that competition during the early stage of market growth is heavily based on product innovations (Abernathy and Utterback, 1978; Geroski, 1995; Klepper, 1997).

Moreover, later studies focusing more on the demand in the industry and product entry show that demand increases following the entry of more products and firms (Agarwal and Bayus, 2002). Since early products in a segment are primitive, demand is limited. As new firms (and their products) enter to the market, they increase the overall product quality by each bringing their own innovation in the hopes of differentiation. This eventually results in increased demand for the market, in addition to well-known supply-side arguments (Agarwal and Bayus, 2002).

Returning to our case, where we look at the trailblazer product entries in the segments, we would expect previous studies at the industry level to hold, due to two main reasons: First, being our interest not a regular product, but rather a trailblazer product, it is plausible to expect they are able to bring more radical innovation to the market/segment they belong to. Second, being our focus at the segment level, we would expect that demand shift due to product innovation to be much stronger than the whole industry level.[46]

Hypothesis 1: *Overall demand in a market segment increases following the release of a trailblazer product to that segment.*

Product Entry into the Segment Following Trailblazer Product

Trailblazer products to a market segment are received with very high demand, due to their qualities. As such, they also create knowledge about the required product features to access this newly discovered pocket of demand for other firms (Argyres et al., 2015). In addition, at the industry level, firms are likely to possess some of the resources and capabilities that would be required to enter the segment following the trailblazer product.[47] Since new information is revealed about the demand and their preferences through the entry of trailblazer product, firms may reduce the uncertainty of entry with their resources and capabilities at hand (Argyres et al., 2015).

Firms already competing in the segment also release new products for two reasons: First, by being threatened with such a product, they retaliate to the trailblazer product innovation and try to limit the advantages by trailblazer innovator. If existing rivals do not retaliate, it would likely allow the trailblazer innovator to dominate the segment over the long-term. Second, existing rivals may also come to think they are in the best position to release their own versions of imitating products since they have existing experience in the market segment.

Hypothesis 2: *Product entry to a market segment increases following the release of a trailblazer product to that segment.*

Incumbent and Entrant Product Sales Following Trailblazer Product

The final piece of our theory is an analysis of average sales of games in a market segment following trailblazer product. Our current hypotheses so far lead to an ambiguous outcome for the average sales of a product. Since the average sales are dependent on relative increase in the overall demand of market segment compared to increase in product entry to the market segment, it could remain same, increase, or decrease. However, we propose that differences between incumbents and

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[46] This argument is also not contradicting to Barroso et al. (2014) study, which finds that too many product availability in the past in a segment creates a “saturation” which reduces demand in a segment. Their argument is based on reduction of novelty in the segment through release of many products, where as trailblazers products are of high novelty (i.e., high quality) by definition.

[47] However please note that Stern and Henderson (2004) shows that resources and capabilities have limited mobility between market segments.

entrants to the segment could lead to different sales performance due to their different capabilities and experience relating the focal segment.

As we mentioned earlier, a new trailblazer product allows firms to observe the combination of product design elements that are favorable for demand in a market segment (Argyres et al., 2015). If firms are able to imitate perfectly, they would likely all benefit by releasing similar products to the market segment. Therefore the degree and ability to imitate the trailblazer product is an important determinant of product sales following the trailblazer.

Incumbents in a market segment and entrants to a market segment differ in their existing capabilities, flexibility, and learning which will change payoffs for releasing a product following the trailblazer. Incumbents possess core capabilities (Helfat and Lieberman, 2002), i.e., technical and customer knowledge relating to the specific market segment, by which they would perform better in the market segment vis-à-vis entrants. Yet, when incumbents would like to imitate trailblazer product to benefit from following demand changes in the segment, they are less able to imitate these products due to their existing capabilities relating to segment. There are three main reasons for this: First, their previous experiences may make them less likely to imitate, but more likely to retaliate with a product that is designed to reinforce their strengths, but not able to respond to newly found demand in the segment. It has been well documented incumbents are generally more inertial due to their existing capabilities, and rather myopic in responding to changes (Leonard-Barton, 1992; Christensen and Bower, 1996; March, 1991). Second, even in the case an incumbent would imitate trailblazer product; it is less successfully able to do so. Literature on learning points out that, when firms imitate others in an attempt to vicariously learn from others' experiences, firms learn less as they have more experience themselves (Ingram and Baum, 1997; Barkema and Schijven, 2008). Although reasons are not widely discussed, a highly likely explanation lies in the interpretation of experience. March, Sproull, and Tamuz (1991) theorize that firms can learn from rare events through interpretations and analysis of possibilities rather than directly experiencing the event. Incumbents, given their previous experiences, are less likely to interpret and analyze the lessons from a trailblazer product, compared to an entrant.

Hypothesis 3: *Games by entrants benefit more than incumbents' games by following the release of a trailblazer product to that segment.*

METHODS

Setting: US Video Game Industry

We test our hypotheses in the population of commercial games released for the fifth-generation and sixth-generation video game consoles during January 1995-December 2007. This setting fits our research questions well. Trailblazer products, dynamics of market segments, and performance of newly developed products each play a central role in this industry. Popularity of segments is closely dependent on the release of trailblazer games, and other firms are widely known to try to follow the success of a trailblazer product in a segment.

Publishers are especially interested in segment dynamics since they would like to profit by taking a slice of demand when a particular market segment becomes high in demand. Publishers take risks by funding game development, and in funding developers, generally: "…publisher decides on the genre it wants, in effect subjugating the initial creative process to a rational decision" (Tschang, 2007, p. 994).

Moreover, the unpredictability of demands' reaction to new games and increasing complexity of the industry creates an important amount of uncertainty (Tschang, 2007). Since "uncertainty is also a powerful force encouraging imitation" (DiMaggio and Powell 1983, p. 151), it plays an important role on how products are developed, especially in the wake of success of a trailblazer product.

Data

Our dataset comes from a combination of sources. List of commercial games, together with their publisher, release date and platform, sales information and market genre come from NPD research, which tracks the monthly sales data of every console game sold through U.S. retail channels for most major retailers. In addition, we collected quality data on games from Mobygames.com, Metacritic.com, and Gamerankings.com. MobyGames website is the oldest and largest online video game archival on the Internet with a well documented policy on contribution on game details (Mollick, 2012). MobyGames uses its own proprietary method to calculate a quality score called MobyRank, by normalizing and weighting review scores from each outlet. Similarly, Metacritic.com and Gamerankings.com provide aggregated and standardized review score for each game title (if available).

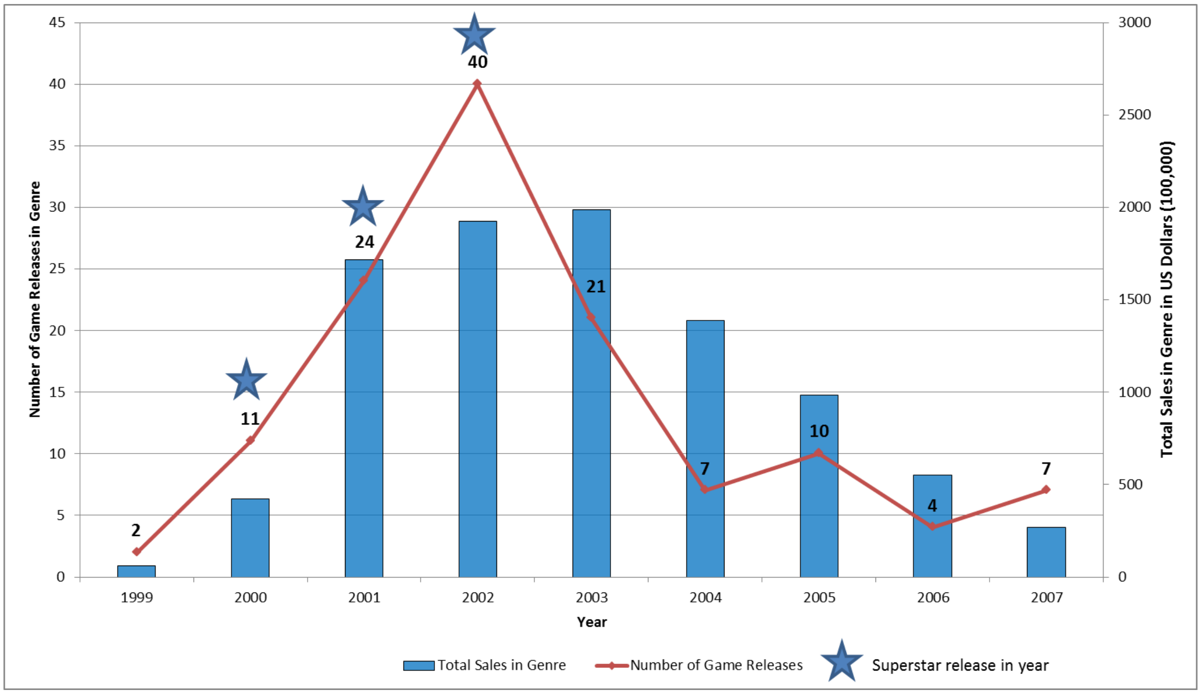
NPD research classifies games into 51 genres, which each represents distinct market segments regarding the development, marketing and consumption of games: these include story, art development, graphic technology, game mechanics, demand segments, marketing, demographics and so on. Therefore different genres require different kinds of specific capabilities to succeed in each genre, which is similar to movie industry as highlighted by Shamsie et al. (2009). However, not all genres include a trailblazer (we will explain how we identified trailblazers below), which would make it more appropriate to not include in our analysis as we would like to observe within-segment changes conditional on the release of a trailblazer product. We have trailblazer product releases only in 21 out of 51 genres. As an example, Figure 14 shows yearly game releases and total yearly sales for the “Extreme Sports” genre through the sixth-generation console cycle, and how game releases as well as total sales in the genre generally increase following the release of a trailblazer game.

Consoles, for which video games are developed, are available in the form of technological generations (de Vaan, 2014). On average every 5 years, a new console generation replaces the old one. Each generation of consoles represent a self-contained ecology itself in terms of games competing with each other, while games from different generations cater to different demand bases. In order to capture market segment dynamics properly, we only analyzed games released for fifth-generation and sixth-generation consoles as we are able to capture from the first trailblazer release to last trailblazer release in any segment during the active period of these console generations.

Our final dataset is composed of 3899 title-platform game releases by 108 different publishers for game sales regressions, and 341 genre-console generation-year observations for market segment entry and demand regressions.

FIGURE 14

Yearly sales and game releases in the extreme sports genre in sixth-generation consoles



Variables

Operationalizing Trailblazers

As mentioned earlier, trailblazers are recognized by their high quality (Rosen, 1981). We used critical review ratings of games as an indicator of product quality, as has been done in the past research (e.g., Archibald, Haulman, and Moody, 1983; Liebowitz and Margolis, 1999). More specifically, Binken and Stremesch (2009) have done an analysis of "superstar" games on console sales, and they have used a quality rating of 90 and above as a cutoff point for determining these games. Figure 1 shows that returns disproportionately increase at higher values of quality scores. Figure 3 shows trailblazing qualities of these games by increasing segment demand and entry. Therefore, we follow Binken and Stremersch (2009) and also adopt 90 as the cutoff point to determine trailblazers.

Another issue concerns sources of quality scores used to determine the measure. Binken and Stremesch (2009) uses a combination of user submitted review scores and critical review scores available in publications and online video game websites.[48] By using our three sources of

[48] But they also note that using only critic review scores produces similar results.

aggregated review scores (Mobygames.com, Metacritic.com, Gamerankings.com), we compared the sample of trailblazer games according to each source, as well as with the sample of supertar games overlapping with our period of observation (1995-2005) in Binken and Stremersch (2009). Although sources generally have minimal differences in scores, Metacritic.com gives us almost perfect match with the Binken and Stremersch sample as it also provides user review scores in addition to critic review scores.

Dependent Variables

To test our hypotheses, we analyze the effect of trailblazer product release in a market segment in a console generation to product entry and total sales at the market segment level within each console generation. We also analyze the effect of trailblazer product release on the sales of individual games in a market segment in a console generation for incumbents of the market segment and entrants into it. Consequently, we construct three distinct dependent variables to support these analyses.

1. Ln(Total Segment Sales)$_{ijt}$ is natural logarithm of sum of yearly sales of games in genre *i* and console generation *j* in year *t*. The variable is logged to have a more normal distribution and also to limit the influence of trailblazers on sales.
2. Number of Product Entry$_{ijt}$ is a count of the number of games released in genre *i* and console generation *j* in year *t*. We also used a logged version of this variable for linear estimations of entry into the market segment-console generation in a year.
3. Ln(Total Game Sales)$_{ij}$ is natural logarithm of total lifetime sales of the game released in genre *i* and console generation *j*.

Independent and Control Variables

Our first independent variable of interest is *Following Trailblazer*, which is a dummy variable that takes value of 1 for the year after a trailblazer is released in a market segment in a console

generation. Using one year lag allows us to evade problems regarding timing. For example, if a trailblazer is released in October (which is common), it would be hard to imagine a game released in December really imitates or adopts feature from the trailblazer game, but it rather follows the surge in demand. However, most of the games are released in Christmas season, and yearly gap allows to more plausibly expect firms to imitate a trailblazer to some extent in their games.[49]

Moreover, since most genres have multiple trailblazer releases in a console generation, they generally overlap in following each other. For example, a trailblazer is released in 2000, and another trailblazer that follows this trailblazer is released in 2001, and so on. Since this may create long spells of times where games follow trailblazers, we further divided *Following Trailblazer* variable into two: *Following 1st Trailblazer* is a dummy variable that takes 1 for the year after the first trailblazer is released in a genre in a console generation. *Following Later Trailblazers* dummy variable takes value of 1 for the year after the second and later trailblazers released in a genre in a console generation. An example would help clarifying our main independent variable. Let's say two trailblazers are released in sixth-generation consoles in the first person shooter genre: one in 2002, another in 2003. According to our variable *Following Trailblazer*, games released in 2003 (following 2002), and 2004 (following 2003), will all take a value of 1, while other games in the same genre and console generation will take a value of zero. Continuing with the same example, *Following 1st Trailblazer* will take value of 1 only for games released in 2003 (following first trailblazer in console generation-genre in 2002), and *Following Later Trailblazers* will take value of 1 only for games released in 2004 (Second trailblazer is released in 2003).

We have also a few control variables. Most importantly, we control for fixed year, genre, and console generation effects in product entry and total genre sales models. We also control for fixed year, genre, platform, publisher, and release month effects in the game sales models.[50] As such we control for inherent heterogeneity between different years, genres, and console generations in their product release and total sales potential. In game sales models, we additionally control for differences between publishers and platforms in affecting sales of a game. Video game industry is heavily dependent on sales in the Christmas season, and as such, both most of the game releases, as well as the most important game releases are done in the last three months of the year. Release month fixed effects control for these quality and competition effects. Besides our fixed effects, we control for the number of years with the console generation and its squred term. Within each

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[49] However we will also discuss importance of using monthly analysis for our purposes, and show some early exploration of that analysis.

[50] Since platforms are within console generations, this effectively controls for console generation effects already.

console-generation, game sales and product releases increase as installed base of the generation increases, and then deccreases over time as the console-generation is ending to a new generation is rising in adoption (Clements and Ohashi, 2005).[51]

Our second independent variable of interest is *Incumbent*. This is a dummy variable that takes the value of 1 if the publisher firm has released a product to the genre before the current product release, and 0 otherwise.

Estimation

To test our genre-console generation product entry hypothesis, where the dependent variable is a count, we estimate negative binomial models. We also estimate an OLS model with logged count of product entries. To test our genre-console generation sales hypothesis we use an OLS model and for genre incumbent and entrant game sales hypotheses we estimate a publisher fixed effects linear model.

Tables 15 and 16 shows descriptive statistics for the data for genre-console generation level models and game sales model, respectively. Correlations are generally quite low, not indicating any problem of possible collinearity (different trailblazer related variables do not enter the model together). It could be also seen from Table 15 that trailblazer related variables are positively correlated with number of game releases and total sales in genre. Also, Table 16 shows that being an incumbent in a segment is positively correlated with game sales, on average.

RESULTS

Genre Demand

Hypothesis 1 predicts that total demand in a genre-console generation increases following the release of a trailblazer product in that genre-console generation. Table 17 presents results for genre level sales estimations, and we can see that sales significantly increase following trailblazers. When we look at the *Following 1st Trailblazer* and *Following Later Trailblazers* separately, we could see that total genre sales increase following the 1st Trailblazer, but not for following later trailblazers. Obviously, demand will be also driven by trailblazers themselves, so we also ran models with not including the yearly sales of the initial trailblazers in the genre-console generation

[51] In the robustness section, we also controlled for additional variables such as competitive crowding, whether trailblazer product is released on the focal platform or on another platform, and saturation (Barroso et al., 2014).

TABLE 15
Means, standard deviations, minimums, maximums, and correlations for genre-console generation level models

	Variables	Mean	S.D.	Min	Max	1	2	3	4	5
1	Genre-Console Generation Game Releases	11.43	13.60	1	120					
2	Genre-Console Generation Total Sales[a]	17.49	1.63	10.19	20.36	.58				
3	Years in the Generation	6.23	2.92	1	13.0	-.12	.04			
4	Following Trailblazer	0.21	0.41	0	1	.33	.42	-.00		
5	Following 1st Trailblazer	0.08	0.27	0	1	.13	.19	-.11	.58	
6	Following Later Trailblazers	0.13	0.34	0	1	.29	.35	.09	.74	-.12

a: Logarithm.
N = 341.

TABLE 16
Means, standard deviations, minimums, maximums, and correlations for game sales models

	Variables	Mean	S.D.	Min	Max	1	2	3	4	5
1	Game Sales[a]	14.84	1.61	4.11	19.60					
2	Years in the Generation	5.81	2.11	1	13.0	.00				
3	Following Trailblazer	0.37	0.48	0	1	.08	.16			
4	Following 1st Trailblazer	0.13	0.33	0	1	.03	-.09	.49		
5	Following Later Trailblazers	0.25	0.43	0	1	.07	.24	.74	-.22	
6	Incumbent	0.83	0.37	0	1	.17	.04	.10	.02	.09

a: Logarithm.
N = 3899.

TABLE 17
Yearly sales of a genre in a console generation following a trailblazer game release in that console generation-genre. OLS Model, DV = Ln(Genre-Console Generation Total Sales)

	Model					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Years in the Generation	0.587	0.759	0.568	0.451	0.624	0.637
	(0.552)	(0.557)	(0.564)	(0.744)	(0.749)	(0.558)
Years in the Generation^2	-0.086***	-0.091***	-0.088***	-0.091***	-0.097***	-0.088***
	(0.010)	(0.009)	(0.010)	(0.013)	(0.013)	(0.010)
Following Trailblazer	0.435***			0.478**		
	(0.128)			(0.172)		
Following 1st Trailblazer		0.461**			0.419^	
		(0.165)			(0.222)	
Following Later Trailblazers			0.237			0.255
			(0.159)			(0.158)
Constant	12.014***	12.341***	11.884***	10.835***	11.075***	12.165***
	(1.406)	(1.418)	(1.432)	(1.893)	(1.909)	(1.416)
Observations	341	341	341	341	341	341
R-squared	0.786	0.783	0.779	0.706	0.706	0.776
Unit of Analysis	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year
Sample	Full	Full	Full	No Non-Following Trailblazers	No Non-Following Trailblazers	No Non-Following Trailblazers
Year FE	YES	YES	YES	YES	YES	YES
Genre FE	YES	YES	YES	YES	YES	YES
Generation FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10

that other games follow (e.g., if we have two trailblazers in years 2002 and 2003, we remove the trailblazer in 2002 only, since the trailblazer in 2003 is a follower game itself). In these more stringent models, *Following 1st Trailblazer* variable becomes only marginally significant. Our results show support for Hypothesis 1, but it is less stronger once we take out demand generated by the trailblazer – however note that our theoretical argument considers the demand generated by the trailblazer as well since that surge in segment demand is a driver of product entry for other firms. In any case, we will return back below to this analysis when we are discussing monthly analysis of market segments rather than a yearly one.

Product Entry

Tables 18 and 19 present results of our test of Hypothesis 2, concerning the product entry into the market segment following a trailblazer product. We explore whether product entries increased following a trailblazer product release in a market segment. In Table 18, we can see that coefficients for *Following Trailblazer* and *Following Later Trailblazers* are significant, while *Following 1st Trailblazer* is only marginally significant. This supports our idea that trailblazer release in a market segment is positively associated with product entry into that segment in the following year. As an additional estimation, we also run linear regression models with logged dependent variable. Table 19 shows these results, and they are very similar in those Table 18, except for the *Following 1st Trailblazer,* which is not significant in this table. We can say that our findings support Hypothesis 2, but this effect is driven from later trailblazers, but not the first trailblazer in a genre-console generation. Since entry effect is driven by later trailblazers, there is a possibility that entry effect could be driven by sheer number of trailblazers in a genre once we observe multiple trailblazers over time. To control for this, we also run models excluding trailblazers from the entry count. Models 4, 5, and 6 in both Tables 18 and 19 show results after excluding trailblazers from entry count, which is in the same line with Models 1, 2, and 3. If we would like to interpret the impact of our finding, we find that according to Table 18, Model 1, a trailblazer in a genre means a 32% increase in entry to a genre in console generation, in the following year of a trailblazer release in that genre and console generation.

TABLE 18
Product Entry following a trailblazer game released in a console generation-genre. Negative Binomial Model, DV = Number of Yearly Genre-Console Generation Game Releases

	Model					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Years in the Generation	0.291	0.404	0.245	0.289	0.398	0.240
	(0.448)	(0.453)	(0.453)	(0.453)	(0.458)	(0.458)
Years in the Generation^2	-0.054***	-0.057***	-0.054***	-0.054***	-0.057***	-0.054***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
Following Trailblazer	0.279***			0.279***		
	(0.076)			(0.077)		
Following 1st Trailblazer		0.181^			0.171^	
		(0.099)			(0.101)	
Following Later Trailblazers			0.250**			0.259**
			(0.094)			(0.096)
Constant	0.205	0.410	0.089	0.158	0.353	0.036
	(1.067)	(1.080)	(1.079)	(1.081)	(1.094)	(1.092)
Observations	341	341	341	341	341	341
Log-likelihood	-936.79	-941.75	-939.90	-932.56	-937.56	-935.31
Wald chi-square	496.07***	486.15***	489.84***	488.66***	478.66***	483.15***
Unit of Observation	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year
Sample of Games	Full	Full	Full	No Trailblazers	No Trailblazers	No Trailblazers
Year FE	YES	YES	YES	YES	YES	YES
Genre FE	YES	YES	YES	YES	YES	YES
Generation FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10

TABLE 19
Product Entry following a trailblazer game released in a console generation-genre. OLS Model, DV = Ln(Number of Yearly Genre-Console Generation Game Releases)

	Model					
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)
Years in the Generation	-0.123	-0.042	-0.175	-0.097	-0.022	-0.153
	(0.340)	(0.345)	(0.344)	(0.349)	(0.354)	(0.353)
Years in the Generation^2	-0.035***	-0.038***	-0.036***	-0.036***	-0.038***	-0.036***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Following Trailblazer	0.268***			0.259**		
	(0.079)			(0.081)		
Following 1st Trailblazer		0.167			0.148	
		(0.102)			(0.105)	
Following Later Trailblazers			0.252**			0.257*
			(0.097)			(0.100)
Constant	-0.183	-0.055	-0.340	-0.160	-0.044	-0.320
	(0.864)	(0.879)	(0.874)	(0.888)	(0.903)	(0.896)
Observations	341	341	341	341	341	341
R-squared	0.738	0.731	0.734	0.729	0.722	0.726
Unit of Analysis	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year	Genre-console generation-year
Sample	Full	Full	Full	No Trailblazers	No Trailblazers	No Trailblazers
Year FE	YES	YES	YES	YES	YES	YES
Genre FE	YES	YES	YES	YES	YES	YES
Generation FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10.

Incumbent and Entrant Game Sales

Our last hypothesis predict that individual game sales of incumbents will not increase following the release of a trailblazer game in a genre-console generation, but sales of entrants will increase. First three models in Table 20 explores if average game sales change following the release of a trailblazer. It shows that only after *Following 1st Trailblazer* there is an increase in sales. This also makes sense in combination of our previous findings on entry and demand. We earlier find that entry was not increasing following the first trailblazer, but total genre demand was increasing. These findings hint us possibilities of finer-grained time based dynamics, which we will be exploring below.

Models 4,5, and 6 test our hypotheses regarding incumbent and entrant sales differences following a trailblazer product. In each model, interaction of Incumbent with the respective Following Trailblazer variables is negative and significant (though it is marginally significant for Model 6). Coefficients for Model 4, and Model 5 point to a situation where following a trailblazer increases game sales, but only for entrants, not for incumbents. These findings support our Hypothesis 3. It can be also seen that in Model 4, incumbents perform better in overall, yet they do not benefit from following trailblazer games.

In order to better understand these results, we seperated our sample by games released for fifth-generation consoles and sixth-generation consoles. Models 7,8, and 9 replicates our results of Models 4,5, and 6 for fifth-generation consoles. Here we have stronger results for *Following Trailblazer* and *Following 1st Trailblazer*, whereas *Following Later Trailblazers* loses its marginal significance. Also note that incumbency dummy is stronger in these models, being significant in both Models 7 and 8. Models 10, 11, and 12 replicates same results for sixth-generation consoles. Here, we have significant results for *Following Trailblazer* and *Following Later Trailblazers*, but not for *Following 1st Trailblazer*. Also incumbency is not related with performance in overall. These results point out us a pattern, which could be explained by the availability of trailblazers in each generation. Fifth-generation consoles are rich in 1st Trailblazers (Atari Jaguar, Playstation, and Nintendo 64), but have only a few second and later trailblazers in a genre during the console generation. On the other hand, sixth-generation consoles (all the rest of platforms), are rich in multiple trailblazers in each genre over time, which is driving our results. In sum, these results point to consistent evidence that following trailblazers, entrants to the genre benefit from increased

TABLE 20. Game Sales of Incumbents and Entrants following a trailblazer game release in that console generation-genre. Publisher Fixed-effect OLS Regression Model, DV = Ln(Game Sales)

	Model											
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Years in the Generation	0.991*	1.029**	1.040**	0.998*	1.044**	1.027**	-0.284***	-0.285***	-0.286***	-0.212	-0.228	-0.218
	(0.390)	(0.389)	(0.391)	(0.389)	(0.389)	(0.391)	(0.045)	(0.045)	(0.045)	(0.186)	(0.184)	(0.186)
Years in the Generation^2	-0.021**	-0.021**	-0.022**	-0.020**	-0.021**	-0.022**	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)	(omitted)
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)						
Following Trailblazer	0.049			0.430***			0.841***			0.405*		
	(0.052)			(0.126)			(0.228)			(0.161)		
Following 1st Trailblazer		0.128*			0.475**			0.971***			0.222	
		(0.065)			(0.168)			(0.239)			(0.242)	
Following Later Trailblazers			-0.047			0.236			-0.287			0.363*
			(0.061)			(0.159)			(0.536)			(0.179)
Incumbent in Genre = 1	0.053	0.053	0.055	0.167*	0.099	0.100	0.254*	0.267*	0.156	0.180	0.035	0.127
	(0.067)	(0.067)	(0.067)	(0.075)	(0.070)	(0.071)	(0.109)	(0.107)	(0.104)	(0.112)	(0.098)	(0.105)
HYPOTHESIZED INTERACTIONS												
Following Trailblazer x Incumbent				-0.439***			-0.649**			-0.439**		
				(0.132)			(0.245)			(0.167)		
Following 1st Trailblazer x Incumbent					-0.406*			-0.782**			-0.190	
					(0.181)			(0.267)			(0.255)	
Following Later Trailblazers X Incumbent						-0.312^			0.335			-0.421*
						(0.162)			(0.549)			(0.182)
Constant	12.321***	12.194***	12.196***	12.213***	12.111***	12.205***	15.624***	12.111***	12.205***	12.213***	12.111***	12.205***
	(1.125)	(1.124)	(1.128)	(1.124)	(1.124)	(1.128)	(0.272)	(1.124)	(1.128)	(1.124)	(1.124)	(1.128)
Observations	3,899	3,899	3,899	3,899	3,899	3,899	1,338	1,338	1,338	2,561	2,561	2,561
R-squared	0.201	0.201	0.201	0.203	0.203	0.202	0.326	0.326	0.326	0.154	0.152	0.153
Number of Publishers	108	108	108	108	108	108	73	73	73	84	84	84
Unit of Analysis	Game	Game	Game	Game	Game	Game	Game	Game	Game	Game	Game	Game
Sample	Full	Full	Full	Full	Full	Full	Gen 5	Gen 5	Gen 5	Gen 6	Gen 6	Gen 6
Year and Month FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Genre and Platform FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Publisher FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10

TABLE 21. Robustness checks for Game Sales Models Publisher Fixed-effect OLS Regression Model, DV = Ln(Game Sales)

VARIABLES	(1) DV=ln(Total Sales)	(2) DV=ln(Total Sales)	(3) DV=ln(Total Sales)	(4) DV=ln(Total Sales)	(5) DV=ln(Total Sales)
Saturation	-0.108^	-0.102^	-0.094^	-0.112*	-0.102^
	(0.056)	(0.055)	(0.056)	(0.056)	(0.055)
Crowding (Other Genres)	0.003*	0.003*	0.002*	0.003*	0.003*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Crowding (Other Genres)^2	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Crowding (Same Genre)	-0.007	-0.006	-0.005	-0.006	-0.006
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Crowding (Same Genre)^2	0.000*	0.000*	0.000*	0.000*	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Years in the Generation	0.064	0.116	0.109	0.033	0.116
	(0.525)	(0.524)	(0.526)	(0.527)	(0.524)
Years in the Generation^2	0.013	0.012	0.011	0.013	0.012
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)
Following Trailblazer	0.483***				
	(0.127)				
Following 1st Trailblazer		0.518**			
		(0.168)			
Following Later Trailblazers			0.263^		
			(0.160)		
Incumbent in Genre = 1	0.189*	0.121^	0.118^	0.073	0.188*
	(0.076)	(0.071)	(0.072)	(0.068)	(0.076)
Following Trailblazer x Incumbent	-0.437***				
	(0.132)				
Following 1st Trailblazer x Incumbent		-0.408*			
		(0.181)			
Following Later Trailblazers X Incumbent			-0.311^		
			(0.162)		
Following Trailblazer in Same Platform				0.088	0.464**
				(0.064)	(0.163)
Following Trailblazer in Other Platforms				0.121^	0.502**
				(0.067)	(0.164)
Following Trailblazer in Same Platform X Incumbent					-0.429*
					(0.168)
Following Trailblazer in Other Platforms X Incumbent					-0.443*
					(0.172)
Constant	14.700***	14.572***	14.646***	14.868***	14.731***
	(1.432)	(1.430)	(1.434)	(1.436)	(1.435)
Observations	3,883	3,883	3,883	3,883	3,883
R-squared	0.208	0.207	0.206	0.206	0.208
Number of Publishers	108	108	108	108	108
Year,Genre,Pub.,Plat.,Month FE	YES	YES	YES	YES	YES

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10

sales, but not incumbents. Also, some models show that incumbents perform better on average, which would be expected from previous literature and our theory.

We also performed some robustness checks for our game sales model. Theory points out two additional possible determinants of performance at the segment level: crowding and saturation (Barroso et al., 2014). Crowding is the density of a segment, as well as total density of all other segments. More crowding in segment may first lead to increases in performance due to legitimacy, and later on decreases due to competition. On the other hand, saturation could be explained by the waning interest in a segment due to too many recent offerings and reduction of novelty in a segment. We ran our models also including variables for crowding and saturation, and as can be seen in Table 21, results remain unchanged for our interactions of interest. Moreover, incumbency becomes more significant in overall in these models. Another possibility is that trailblazers affect sales of following games only on the platform they are released for. For example, if a trailblazer is released for Playstation 2, it may have no effect for the games on Dreamcast. Or another possibility is that, games released for Playstation 2 may get penalized, while games released on another platform will get boosted. For this reason, we created two variables, *Following Trailblazer in Same Platform* and *Following Trailblazer in Other Platforms.* As can be seen in model 5 of Table 21, results do not change even when we separate the platform of release for the trailblazer game. These results add further confidence for our findings on Hypothesis 3.

Additional Analysis: Monthly Game Releases and Total Sales of Genres

Since this is a dynamic industry, it is important to look more fine-grained data on timing of entries and sales. This is especially important if we would like to seperate out if our findings were driven due to demand increase only in the months following the release of a trailblazer game (a pure demand effect), or demand increases some other time later (e.g., 6 months later), so that trailblazer following game releases have enough time to really imitate this game (demand and supply effect).

However, we also have some important hurdles in doing such analysis. First of all, video game industry is heavily biased through Christmas season releases, and although controlling for month fixed effects alleviates some of problems, still it is not a perfect solution as also some genres tend to be biased to certain months (for example sports games almost always released in Christmas season, while a general action genre release can occur in any month). Moreover there is a self-selection of release dates by publishers according to quality: for example, blockbuster titles are released in the Christmas season. For these reasons, we will only provide some exploratory analysis we did so far for monthly game releases and total sales of genres.

Models 1,2, and 3 of Table 22 shows monthly entries according to the three different time windows: 1-6 months, 7-12 months, and 13-18 months following the trailblazer. Model 1 shows that actually entry affect wanes over time as each month passes. This is intersting since early entrants following a trailblazer is much less likely to have developed their products according to trailblazer, but they may as well hope to free-ride from the increased demand by joining the market segment. Comparing *Following 1st Trailblazer* and *Following Later Trailblazers* variables show a more interesting situation. While the former becomes significant only after a considerable time lag, the other one is very strong early on, and gets less important later. These results in total show additional support for our Hypothesis 1.

Models 4,5, and 6 of Table 22 show monthly total sales in genre-console generation, again by looking at our variables defining three time windows. First, here we see that none of our independent variables are significant in Model 4, which may seem contrary to our previous findings. However, looking at Models 5 and 6 clarifies these results. On one hand, sales increases as time passes by *Following 1st Trailblazer*, from significant and negative effect to significant positive effect. Note that in these regressions we do not include the sales done through the initial hit, and this shows that actually demand is repressed in the genre right after the release of the 1st Trailblazer, which we can say that all demand is appropriated by the trailblazer itself. This is also plausible since we found that entries do not increase following the first trailblazer. On the other hand, looking at *Following Later Trailblazers variable,* there is an increasing trend over time, in line with our expectations. In sum, these results provide both supportive evidence to our Hypothesis 2, as well as explain our earlier results in Table 17, Model 5 that there is only a marginally significant effect in the demand increase once we take out demand for the 1st Trailblazer game itself.

TABLE 22. Monthly Analysis of Genre-Console Generation Negative Binomial Model for Models 1, 2, and 3. OLS Model for Models 4, 5, and 6.

VARIABLES	(1) DV=ln(Genre-Console Generation Monthly Entry)	(2) DV=ln(Genre-Console Generation Monthly Entry)	(3) DV=ln(Genre-Console Generation Monthly Entry)	(4) DV=ln(Genre-Console Generation Yearly Sales)	(5) DV=ln(Genre-Console Generation Yearly Sales)	(6) DV=ln(Genre-Console Generation Yearly Sales)
Years in the Generation	0.054	0.177	0.022	1.888***	1.837***	1.192***
	(0.382)	(0.383)	(0.384)	(0.260)	(0.256)	(0.215)
Years in the Generation^2	-0.042***	-0.046***	-0.042***	-0.108***	-0.108***	-0.089***
	(0.008)	(0.008)	(0.008)	(0.005)	(0.005)	(0.004)
Following Trailblazer (1-6 Months)	0.309***			0.035		
	(0.069)			(0.073)		
Following Trailblazer (7-12 Months)	0.268***			-0.088		
	(0.073)			(0.076)		
Following Trailblazer (13-18 Months)	0.172^			0.097		
	(0.090)			(0.091)		
Following 1st Trailblazer (1-6 Months)		-0.016			-0.786***	
		(0.104)			(0.103)	
Following 1st Trailblazer (7-12 Months)		0.140			-0.515***	
		(0.099)			(0.102)	
Following 1st Trailblazer (13-18 Months)		0.190*			0.392***	
		(0.097)			(0.101)	
Following Later Trailblazers (1-6 Months)			0.337***			0.300***
			(0.089)			(0.080)
Following Later Trailblazers (7-12 Months)			0.236**			0.182*
			(0.088)			(0.077)
Following Later Trailblazers (13-18 Months)			0.112			0.168^
			(0.112)			(0.094)
Constant	-2.103*	-1.885*	-2.128*	13.099***	13.026***	12.414***
	(0.892)	(0.895)	(0.896)	(0.671)	(0.662)	(0.551)
Observations	3,957	3,957	3,957	3,957	3,957	3,957
R-squared				0.634	0.648	0.687
Unit of Analysis	Genre-console generation-month	Genre-console generation-month	Genre-console generation-month	Genre-console generation-month	Genre-console generation-month	Genre-console generation-month
Sample	Full	Full	Full	No Non-Following Trailblazers	No Non-Following Trailblazers	No Non-Following Trailblazers
Year FE	YES	YES	YES	YES	YES	YES
Genre FE	YES	YES	YES	YES	YES	YES
Generation FE	YES	YES	YES	YES	YES	YES
Month FE	YES	YES	YES	YES	YES	YES

Standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05, ^ p<0.10

DISCUSSION

This paper has sought to open a conversation on the importance of unique trailblazing products for the evolution of segments and competitive dynamics between entrants and incumbents. To date, industry evolution literature generally not dealt importance of such products. We propose that both demand of the market segment and product entries to the segment will increase following the trailblazer product. Further, we proposed that benefits of the increased demand due to trailblazer product will spillover to the entrants, rather than incumbents. This is due to the better imitation disposition and ability of entrants, rather than incumbents that are inertial due to their previous capabilities developed in the segment.

Evidence from the US Video Game Industry largely conforms to predictions of our theory. Overall, we found that all three of our theoretical predictions enjoy descriptive, as well statistical support. We believe our findings add credibility to our idea that trailblazing products need to be considered to gain insights on evolution of segmented industries, as well as competitive dynamics between entrants and incumbents. Relatedly, we further found that there are differences between the first trailblazer product and later trailblazer products in a segment. Combined with our early exploration of monthly data anlaysis, these findings are critical for future research on this topic.

Theoretical and Managerial Implications

Most interesting insights from our findings come from the changes in demand in the segment, and how this increased demand is distributed to incumbents and entrants. Our finding that trailblazer products increase the demand in a market segment, extends findings of Bayus and Agarwal (2002) to a segmented market setting, and also highlights the role of more unique type of products in driving the demand – rather than run-off-the-mill products introducing minimal innovation. We also complement the study by Barroso et al. (2014), which found that saturation in market segments decreasing product life, due to decreased demand and interest. Our findings show that a complete understanding of market segment dynamics can be achived by considering both saturation, which reduces novelty and interest, and trailblazer product innovations, which increases novelty and demand. When there are no more trailblazer innovations arriving to the segment, it is left only a with a little amount of "diehard" demand base of that particular segment.

Moreover, our results help bring a new light on the incumbent and entrant dynamics. Incumbent and entrant dynamics is a key interest to the industry evolution literature. Yet, we had limited explanation so far if incumbents or entrants perform better within a market segment. We show a mechanism on how entrants are able to perform better in a segment by following a trailblazer product – imitation. We also found some evidence that incumbents on average perform better due to their core capabilities relating to a segment (Helfat and Lieberman, 2002). We see more opportunities to study entrant and incumbent dynamics at this micro-level of analysis to further inform the long standing industry evolution and strategy questions relating to incumbent and entrant dynamics.

Finally, our results have clear implications for managers. If a firm would like to join the hype in a market segment, and would like to do so in a imitative fashion, our findings suggest entrants to the market segment to follow their ideas and join the segment with their own product, but we couldn't suggest the same for incumbents. They could rather wait for better moments – when segment more stable – and apply their own capabilities to release their products rather than following the herd.

Limitations and Directions for Further Research

There are several limitations of our study that we recognize. First, we couldn't control completely for the endogeneity in the entry decision to market segment. However, Barroso et al. (2014) present a solution in the form of a dynamic panel estimator, which uses differences between time period lags as an instrument. Another possibility is to instrument the likelihood of entry to a market segment by using activity in other genres.

Second, we mostly utilized a yearly approach in our analysis, but it limits our understanding of market dynamics due to importance of using finer-grained time windows in a dynamic industry such as US Video Game Industry.

Finally, we used market categorization provided by the data source as different market segments, but Barroso et al. (2014) point out that many products in the same segment may have completely different attributes, pointing to understanding further categorizing our market segments.

Our research opens up directions for further research. First of all, we have only limited knowledge on how trailblazer products change market dynamics, and this study presents an example on how focusing on such products help us in explaining long standing questions of strategy. Second, this study provides an important extension to incumbent and entrant dynamics, and future studies could focus on rare events (such as trailblazer product release) and ensuing competition (e.g., imitative entry) in explaining these dynamics. Last, studies at the market segment level with micro-level data on products could extend our research by looking at trailblazers and their relationships with market segment dynamics.

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