Dancing in the Dark: Essays Concerning Innovation Productivity

Michael Steve Houston

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DANCING IN THE DARK: ESSAYS CONCERNING INNOVATION

PRODUCTIVITY

By

Michael Steve Houston

A Dissertation

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Doctor of Philosophy

Major: Business Administration

The University of Memphis

December 2023
Dedication

To my very patient and supportive wife, Lori Stone: This would not have happened without your steadfast belief in me. You have supported this endeavor since the beginning and have been a sounding board for every crazy idea that popped into my head. You bore the brunt of my stress and late-night rants as I completed coursework and began writing this dissertation. Your support never wavered through the good times and the bad, even as you dealt with COVID patients and all the attendant stress that entailed. Although I now have the honor of the title "Dr.", it belongs as much to you as it does to me. I love you, Lori! I am also very thankful for a wonderful and supportive family. My mother, Marie, would be very proud that her son is the family's first "Dr.". My sister Linda has always been incredibly supportive of my academic career, and my niece Tracy taught me a thing or two about persistence and chasing your dreams. To the rest of my Memphis family. Lauren, AJ, Greyson, Ian, and Ashlee: I love you all and am blessed to have you in my life. To my California family, Marisa, and Chris, thank you for the encouragement and for continually asking, "When are you graduating?" To my Beaufort family, Bernie and Tracy, Tara and Jason, and so many others: Thank you for being my refuge when I needed to run away and your encouraging words that sent me back. Special thanks to those who went through this with me: Jenny, Courtney, Jerry, and Becca. I am honored to call you all both colleagues and friends. For everyone else who endured my dissertation phase, it is done.
Acknowledgments

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Abstract

Innovation and related investment are key to a firm’s ability to survive and experience continued growth. Understanding how that investment translates to a firm’s performance continues to be a key area of focus for strategy researchers. Utilizing a measure developed in the management literature (RQ) that seeks to better understand how R&D translates to firm performance, this study examines the moderating effects of contextual variables (the CEO/TMT pay gap, munificence, and dynamism) that impact this relationship. The results support that pay gap has a positive effect on the innovation – firm performance relationship while low munificence and high dynamism both acted as suppressors.

There is no question that innovation is important, not only for firm growth but for overall economic growth. The literature is replete with studies that examine the drivers of innovation, but very few examine product-market choice as one of those drivers. This study utilizes data generated from high-technology software manufacturers as well as data from the Hoberg-Phillips Data Library to examine the relationship between product-market strategies (differentiation and vertically integrated product line) and innovation productivity. Our results offer support that product-market strategy can have a bolstering effect (vertically integrated product line) or a suppressing effect (differentiation). Product market density and strategic execution were found to have positive effects on the relationship.
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Introduction

Innovation is the process of bringing new offerings to market and is one of the most important issues in business research today (Hauser, Tellis, & Griffin, 2006). Innovation is responsible for lowering prices while raising the quality of products and services which in turn improves consumers’ lives. Through finding solutions to consumer’s problems, innovation acts as creative destruction (Schumpeter, 1942) by destroying existing markets, transforming old ones, and creating new ones. Marketing, as a discipline, is well positioned to contribute to the understanding and management of innovation efforts within firms and markets. Given that a primary goal of innovation is the development of new or modified products that result in superior firm performance, marketers must drive revenue through satisfying consumer needs more efficiently and effectively than their competitors. While practitioners and scholars agree upon the importance of innovation in driving superior organizational performance, the innovation literature offers only limited guidance with respect to how organizations can systematically improve innovation success rates.

Innovation cannot be understood as a smooth, well-behaved linear process. Innovation is complex, uncertain, and subject to all sorts of change. Much of this change can be thought of as the unpredictable and sometimes subtle interaction of two sets of forces: market factors and scientific progress. Thus, the process of innovation could be thought of as an exercise in the management and reduction of uncertainty (Kline & Rosenberg, 2010). Any attempt to try and understand innovation requires the exploration of a number of dimensions and in this dissertation, we examine innovation as both an independent variable (essay 1) and as a dependent variable (essay 2). Innovation is difficult to measure and demands constant coordination of resources that keep abreast of internal considerations such a governance
structures and compensation, product-market strategy selection, and exogenous shocks resulting from market dynamics.

CEO compensation packages have long been a point of contention in the management literature and are thought by some researchers to dilute value from the firm and shareholders (Calian, 2002; Eisinger, 2006). One aspect of CEO compensation that has garnered recent attention is the CEO - TMT pay gap. The pay gap between CEO’s and their TMTs could be thought of as the reward expected by non-CEO’s if they were promoted to CEO. Tournament theory (Lazear & Rosen, 1981; Rosen 1986) is an economic theory based on competition as a means of addressing the classic principle-agent problem. Competitors for promotions become contestants in a single elimination contest where the promotion (pay gap) is the prize. This compensation method ties aspects of a CEO’s compensation to the long-term outcome of the firm, and it is thought that this type of compensation will keep CEOs from trading short-term gains for more lucrative long-term incentives. Prior research examining the CEO pay gap has resulted in less than consistent results (Carpenter & Sanders, 2004; Eriksson, 1999; Henderson and Frederickson, 2001).

Product-market strategy relates to how firms choose to compete within their chosen markets (Hughes & Morgan, 2007). The overall effectiveness of a product-market strategy depends upon the effective and efficient use of firm resources in executing said strategy. The motivation behind examining the role played by the product market stems from the observation that firms invest in R&D because they wish to gain a product market advantage (e.g., greater product quality or a lower marginal cost). So, the question of interest becomes, does the choice of product-market strategy impact innovation output and if so, in which direction? The choice of
product-market strategies, herein meaning differentiation or vertical integration of a firm’s product line, has scantly been investigated as a factor impacting innovation productivity.

Exogenous shocks or changes occurring in the environment outside the firm can and do impact a firm’s overall performance. The two measures often examined in terms of exogenous variables are munificence and dynamism. A munificent environment is marked by overall market growth and increased opportunities. Munificent environments also allow firms the opportunity to acquire additional resources which can be converted into additional capabilities (McEvily & Zaheer, 1999) creating an upward spiral that would support innovation activities. Dynamism is a measure of stability and how quickly the environment is changing. Several empirical studies show that the greater the uncertainty in the environment the greater the environmental dynamism (Duncan, 1972; Milliken, 1987, 1990; Tung 1979) and thus the greater the need for firms to innovate to survive. In addition to the measures of munificence and dynamism, we should also consider the competitive space within which a focal firm operates. In each product-market segment that a firm operates, they have a set of rivals that could be thought of as more similar or less similar based on their location as represented in a graph.

The essays that follow will try to shed some additional light on our understanding of how firms can be more successful in their innovation attempts through internal governance structures (CEO -TMT pay gap), selection of product-market strategies, and awareness and understanding of the role of environmental factors that influence innovation relationships within the firm. Utilizing a resource-based view of the firm (essay 1) and a resource advantage theory of competition, the following essays will investigate these influences and offer theoretical and practical implications. Following is an abstract for each essay.
Essay 1

The argument that a firm’s innovation capability and overall performance exhibit a positive relationship has found support in several studies from various industries including pharmaceuticals (Roberts, 1999), biotechnology (DeCarolis & Deeds, 1999), and computers (Hua & Wemmerlov, 2006). However, this positive relationship seems an incomplete explanation of the innovation - firm performance linkage given a failure rate of 35 – 45%. Essay 1 attempts to examine the impact of an internal corporate governance factor (CEO-TMT Pay Gap) as well as two environmental variables (Munificence and Dynamism) on a risk-adjusted, forward looking measure of firm performance (Tobin’s Q). A random effects regression model will assess the direct effect of a new measure of innovation capability (Research Quotient, RQ) on firm performance. It is hypothesized that (a) innovation capability will have a positive effect on firm performance, (b) a larger pay gap between the CEO and the TMT will have a positive effect, and (c) higher levels of munificence and dynamism will have a dampening effect on the innovation capability and firm performance relationship. Support for these hypotheses, analysis and methodology are discussed along with theoretical and managerial implications.

Essay 2

There is no question that innovation is important, not only for firm growth but for overall economic growth. The literature is replete with studies that examine the drivers of innovation, but very few examine product-market strategy as one of those drivers. This essay seeks to examine the relationship between product-market strategy choice and innovation productivity. Based on Resource Advantage Theory, this essay proposes that a product differentiation strategy will impede innovation productivity while a vertically integrated product line will bolster productivity. Additionally, this study proposes two new environmental variables, ability to
execute and product-market density and their moderating effect on the product-market strategy choice and innovation productivity. The firm’s ability to execute strengthens the relationship between product-market strategy and innovation productivity while the product market density measures offered less robust results.

Conclusion

Not only do these two essays provide some interesting theoretical implications, but also practical ones, specifically for the board of directors, managers, and marketers. Support is found for the tournament theory perspective for the role of the CEO -TMT pay gap and how it can influence the innovation → firm performance relationship. These essays also demonstrate the importance of understanding the strong influence of environmental variables on our understanding of the strategy → innovation → firm performance linkage. These findings are discussed further in each essay.
II. Take the Long Way Home: Contextual Factors Impacting the Innovation – Firm Performance Relationship

Michael S. Houston

University of Memphis
Abstract

Innovation and related investment are key to a firm’s ability to survive and experience continued growth. Understanding how that investment translates to a firm’s performance continues to be a key area of focus for strategy researchers. Utilizing a measure developed in the management literature (RQ) that seeks to better understand how R&D translates to firm performance, this study examines the moderating effects of contextual variables (the CEO/TMT pay gap, munificence, and dynamism) that impact this relationship. The results support that pay gap has a positive effect on the innovation – firm performance relationship while low munificence and high dynamism both acted as suppressors.
Introduction

Innovation is essential for firm survival and growth and is considered a primary source of sustainable competitive advantage. Innovation is understood to be generated by productive investments in R&D capabilities (Helfat, 1997) which, in turn, drive economic growth (Arrow, 1962; Griliches, 1979; Nelson, 1959). According to a report issued by the National Science Board, R&D conducted in the United States totaled $547.9 billion as of 2017, with global investment estimated at $2.13 trillion (NSB-2020-3, 2020). The quality of firm innovation efforts may also be reflected through patenting of new discoveries and subsequent citations. According to a report by the World Intellectual Property Organization (WIPO), patent applications have been growing every year since 2004 with 3.3 million patent applications worldwide in 2018 (WIPO, 2019). According to an article from McKinsey Group, organizations globally spent $2.3 trillion on R&D in 2019 (Brennen, Ernst, Katz, & Roth, 2020). CEOs recognize that innovation is a key factor in firm success but continue to struggle with getting innovation to pay off (Schwartz, 2006). Inge Thulin, President and CEO of 3M (2017) projected 40% of 2017 revenues would come from products that did not exist 5 years ago.

While practitioners and scholars agree upon the importance of innovation in driving superior organizational performance, the innovation literature offers only limited guidance with respect to how organizations can systematically improve innovation success rates. According to Harvard professor Clayton Christensen each year approximately 30,000 new products are launched and 80% of them fail (Christensen, 1997). Crawford (1979; 1987) performed literature reviews and after eliminating unsupported or anecdotal reports found a failure rate of around 35%. This substantially lower number is supported by two studies (Griffin, 1997; Adams, 2004) done by the Product Development and Management Association (PDMA) finding failure rates of
42% for the years 1985-1989, 40% for 1995, and 46% for 2003-2004. Given a probable failure rate of between 35 – 45% it is imperative that firms develop more accurate measures to understand and evaluate innovation initiatives (Edison, Bin Ali, & Torkar 2013). A recent survey conducted by the Journal of Product Innovation Management (JPIM) of AE and ERB members identified innovation success metrics as an important theme that needs additional research (Rindfleisch, Mehta, Sachdev, & Danienta 2020). Assuming even a moderate failure rate, the ability of firms to continuously innovate is essential to firm performance (Bettis & Hitt, 1995; Helfat & Peteraf, 2003). The argument that firms innovation and performance exhibit a positive relationship has found support in several studies from various industries including pharmaceuticals (Roberts, 1999), biotechnology (DeCarolis & Deeds, 1999), and computers (Hua & Wemmerlov, 2006). However, this positive relationship seems an incomplete explanation of the innovation - firm performance linkage. The extent to which firms can reap the full benefits of these innovations is typically determined, at least partially, by legal protections such as patents. While patents serve a purpose, especially for larger firms, they may not be the best indicators of innovation for smaller firms (MacDonald, 2004), and by extension, as an explanation of the innovation - firm performance relationship.

For the most part, prior empirical work in this area has relied upon measures such as R&D expenditures, patent activity or patent citation counts, firm stock returns around patent granting data (Kogan, Papanikolaou, Seru, & Stoffman 2017), stock returns in relation to innovation press releases (Mukherjee, Singh, & Zaldokas 2017), or the count of unique classes of patents (Hirshleifer, Hsu, & Li 2018). Observers have noted that such measures suffer from key limitations that hinder their ability to fully capture the quality of firm innovation efforts (Abrams, Akcigit, & Popadak 2013; Hall, Jaffe, & Trajtenberg 2001; Scherer & Harhoff 2000).
Less than 50% of the firms that report R&D activity in COMPUSTAT actually file for any patents. Thus, use of patent or citation data to capture innovation not only may constrain statistical power by reducing sample size, but the practice may also provide an incomplete view of innovation activity occurring across the broader population of firms. A second concern with use of patent or citation counts as a metric of innovation performance is the inherent assumption that their value is uniform. A study conducted by Scherer and Harhoff (2000) demonstrated that only about 10% of U.S. patents account for as much as 85% of the economic value of all U.S. patents. Developing accurate R&D metrics is a complex endeavor for many reasons, the least of which is that a 2004 study by the European Industrial Research Management Association (EIRMA) lists over 250 potential R&D metrics (Schwartz, Miller, Plummer, & Fusfeld 2011). Hall, Mairesse, and Mohnen (2010) caution that capturing returns to R&D is not an “…invariant parameter, but the outcome of a complex interaction between firm strategy, competitor strategy, and a stochastic macro-economic environment” that is constantly changing. More specifically, many of these metrics are determined by a firm’s accounting practices which can differ by industry, sector, and even firm. Table 1 offers a short list of research that has been done concerning the innovation – firm performance relationship.
### Table 1

Selected Literature Concerning Innovation and Firm Performance

<table>
<thead>
<tr>
<th>Study</th>
<th>Empirical Context</th>
<th>Outcome Variable</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrams, Akcigit, &amp; Popadak (2013)</td>
<td>Proprietary dataset including patent specific revenues</td>
<td>Revenue</td>
<td>inverted-U relationship between patent value and citations Some very high-value patents receive substantially fewer citations than less valuable patents.</td>
</tr>
<tr>
<td>Artz, Norman, Hatfield, and Cardinal (2010)</td>
<td>Sample of 272 firms for 19 one-year periods.</td>
<td>After-tax ROA; average sales growth over a three-year period.</td>
<td>R&amp;D spending was positively related to patents. While a significant curvilinear relationship exists between R&amp;D spending and product announcements, it is not the predicted inverse-U but instead a U-shaped relationship. A negative relationship was found between patents and both ROA and sales growth.</td>
</tr>
<tr>
<td>Demirel and Mazzucato (2010)</td>
<td>3295 pharmaceutical firms between 1950 and 2008</td>
<td>% change in sales</td>
<td>It is found that the growth advantage of small pharmaceutical firms increases after the 1980s as small firms become more active in patenting and their patenting activities become more ‘persistent’. Location is found to affect growth differences only for the most innovative firms (that is, for non-innovative firms, location does not matter).</td>
</tr>
<tr>
<td>Kogan, Papanikolaou, Seru, &amp; Stoffman (2017)</td>
<td>158,739 firm-year observations including 15,787 firms in the 1950–2010 period.</td>
<td>Firm stock returns</td>
<td>Patent-level estimates of private economic value are positively related to the scientific value of these patents, as measured by the number of citations that the patent receives in the future.</td>
</tr>
<tr>
<td>Rousseau, Mathias, Madden, and Crook (2015)</td>
<td>Meta-analysis of 62 studies encompassing 23,000 firms.</td>
<td>ROA, ROS, ROI, stock price, sales growth, and market share</td>
<td>Through a meta-analysis of 62 studies over 20 years, this paper confirms a strong linkage between innovation and performance</td>
</tr>
<tr>
<td>Current Research</td>
<td>Innovation capability was operationalized using RQ on a sample of 2947 firm-year observations.</td>
<td>Tobin's q</td>
<td>Innovation capability has a strong effect on firm performance. The CEO/TMT pay gap bolsters this positive relationship. Munificence weakens the relationship as does dynamism.</td>
</tr>
</tbody>
</table>
A second set of concerns obscuring understanding of the link between innovation and firm performance involves the selection of performance outcomes and associated metrics. By their very nature, innovation-related investments are likely to have longer-term payouts. In many cases, these investments carry risk and their associated returns are typically not normally distributed. Therefore, it may be difficult to establish consistent links between innovation and accounting-based measures of firm performance (e.g., ROI, ROA). Accounting measures have been shown to be insufficient when it comes to measuring shareholder value (Rappaport 1986) and contain little to no information about the firm’s future (Geyskens, Gielens, & Dekimpe 2002) thus they are oriented on past performance. Perhaps a better measure for examining innovation and firm performance would be one that is forward looking so it can better accommodate the time horizon of innovation. Tobin’s q is a forward looking, capital market based measure of a firm’s value and is widely accepted as a measure of a firm’s performance (Anderson, Fornell, & Mazvancheryl 2004). The forward orientation comes from the underlying supposition of efficient markets and thus the market can assess future revenue stream in consideration of stock price. Most importantly, Tobin’s q has been adjusted for market risk and is thus not as susceptible to variances in accounting practices which makes it a much better for comparing firms across differing industries.

Finally, the absence of consistent findings with respect to a direct relationship between innovation and performance suggests the possibility that the relationship may be conditional. That is, differences between organizations at the executive, firm, and industry-level may have a substantial influence on the innovation→firm performance pathway. For instance, prior research has established the importance of the CEO in trying to understand firm performance and innovation (Jensen & Meckling 1990; Malmendier & Tate 2005; Galasso & Simcoe 2011). CEO
demographic (insider vs. outsider, age) or features of their compensation (e.g., long-term incentive pay) could impact decision making that would influence the nature and magnitude of innovation investment. Likewise, firm-level features such as financial leverage or available slack could directly impact the firm’s ability to sustain innovation activities. Finally, at the industry level, environmental uncertainty dimensions (e.g., munificence, dynamism) could dramatically impact the availability of innovation-related resources or diminish (enhance) firm returns on innovation investments.

The present research aims to mitigate these challenges, providing new evidence that informs the ongoing innovation→performance discussion. We address the noted problems associated with measuring firm innovation through use of the Research Quotient (RQ) metric (Knott, 2008). RQ is embedded in a firm’s production function and is defined as the firm-specific output elasticity of R&D spending (Cooper, Knott, & Yang, 2015). Grounded in resource-based theory, we present and test a model that links firm innovation (as measured by RQ) to Tobin’s q. Tobin’s q offers certain advantages in this context, as it provides a risk-adjusted, forward-looking view of shareholder evaluations of the net present value of the firm’s future cash flows (Anderson et al., 2004). Furthermore, we test the moderating effects of CEO-TMT pay gap, financial leverage, environmental hostility, and environmental dynamism in shaping the innovation-performance relationship.

Investing in innovation is an inherently risky and expensive endeavor. Study findings provide managers, investors, and stakeholders with unique new insights with respect to the innovation-performance relationship. First, the robustness of study results supports use of RQ in strategy and financial research examining antecedents and outcomes of firm innovation. Second, the study is amongst the first to examine how features of CEO and TMT compensation influence
innovation performance outcomes. In alignment with tournament theory, study findings suggest that financial benefits of innovation activity are strengthened for firms with greater CEO-TMT pay gaps. Third, study findings suggest that more highly leveraged firms could see higher abnormal returns following taking on more debt depending on the firm’s R&D intensity (Alam & Walton 1995; Zantout 1997) although R&D intensive firms tend to have lower average leverage. Finally, our results suggest that the effects of innovation on financial performance may be mitigated for firms competing in more hostile and dynamic industries.

The remainder of the paper is organized as follows. First the theoretical and conceptual framework is outlined. Then a set of hypotheses explaining how certain firm and organizational environment factors influence the direction and magnitude of firm performance response to innovation efficiency. The methodology and the results will follow and then the paper will conclude with a discussion of implications for academics and practitioners, as well, as limitations encountered.

**Study Background**

_Problems Measuring Innovation_

A firm’s ability to innovate is essential to its continued growth and performance. The realization that innovation is related to financial performance begs the question of how firms measure innovation (R&D spend) and what factors (i.e. governance structure, industry, and firm characteristics) might moderate that relationship. The ability to measure the level of innovation generated by a firm is therefore critical for understanding this link. Previous attempts to measure innovation have been one of three types. First, are input measures such as simply the amount spent on R & D activity. Second are output measures such as patents and/or citations. Lastly are efficiency measures which indicate a firm’s ability to turn inputs into outputs such as scaling
patents by R & D costs. All of these measures have specific weaknesses which could lead to misguided or deficient inferences regarding the determinants of innovation.

Patent-based measures suffer from two main problems: they are not universal, and they are not economically uniform. Research has shown that fewer than 50% of firms in COMPUSTAT ever file patents (Cooper et al., 2015). Thus, if patents are used as measure of innovation, many firms that are performing R&D will appear as if they are not innovating at all. Another problem with patent-based measures is that the decision to file for a patent or not is endogenous to firm policy. Firm’s may have many reasons for not filing patents such as protecting the technology or knowledge generated. Patents are also expensive and would require certain disclosures some companies might rather keep in-house and protected.

The second problem with patent-based measures is that they are not of uniform value economically. One study (Scherer & Harhoff, 2000) states that only 10% of U.S. patents account for as much as 85% of the economic value. To try and compensate for this weakness, researchers using patent-based measures would weight the measure by the number of citations or just use the total number of citations instead. This was an improvement. Hall, Jaffe, and Trajtenberg (2001) demonstrated that patent citations were a better indicator of firm value than then number of patents. Another contributing factor to the uniformity problem is the time horizon for citations to materialize. Older patents that only have marginal value might receive more citations then newer, ground-breaking ones. Hall, Jaffe, and Trajtenberg (2001) refer to this as the truncation bias. Given these shortcomings with patent-based measures, researchers looked to alternative firm-level measures of innovation.

Theoretical Support for RQ
Absorptive capacity is the principle that to assimilate new knowledge you first must have knowledge (Cohen and Leventhal, 1989, 1990). In its’ most basic form absorptive capacity states that a firm’s benefit from external knowledge should increase as their own R&D increases. The inference being that firms should invest more in R&D to gain more benefits from spillover. Cohen and Leventhal (1989,1990) demonstrate a functional form of absorptive capacity as an interaction between a firm’s own R&D and spillovers. The fact that this interaction was positive and significant raised another question; would not it be likely that the firms only performing a small amount of R&D (<= 5%) would just imitate the technological leader and thus no gains to spillover for the leaders. If this is true, then why is the interaction described above positive and significant? Knott (2008) identified a possible solution. Perhaps R&D investment is, “endogenously determined by a more fundamental capability, something we will refer to as organizational IQ”. (p. 2054). Knott (2008) goes on to equate personal and organization IQ as a complex process of dealing with new information. In its organizational form, this measure of IQ would be how the firm uses new information to deal with previously unsolved problems. Thus, organizational IQ could be measured as an output elasticity of R&D investment (later called RQ for Research Quotient). The conclusion reached by Knott (2008) was that firms have differing levels of organizational IQ and that the higher IQ’s invest more in R&D. Thus, it is not more investment in R&D that drive returns, as absorptive capacity states, but having higher returns (RQ) seems to increase investment.

Romer’s Theory of Endogenous Growth

The foundation of Knott’s RQ measure is Romer’s (1990) theory of endogenous growth. Building from Solow’s (1957) idea that approximately 2/3 of economic growth was due to “technological change”, Romer provided the path by which said change occurred. Romer added
knowledge to the typical aggregate production function (capital and labor). Knowledge was a means of increasing output from capital and labor (i.e., “technological change”) but the larger contribution from Romer was linking knowledge with purposeful investment in R&D. Specifically, Romer (1990) states that the amount of new knowledge obtained from R&D is a function of 1) the level of prior knowledge, 2) the amount of R&D, and 3) the productivity of converting that R&D into new knowledge. The key insight from Romer’s theory is that growth from R&D is comprised of two parts: the amount of R&D spending and the associated productivity. The failing of previous measures of innovation was primarily a failure to account for the productivity part of this theory. Knott and Vieregger (2019) test three common measures of innovation (patent intensity, total factor productivity (TFP), and RQ) and only RQ satisfies the requirements for R&D productivity put forth in Romer’s theory.

*Research Quotient (RQ)*

Research quotient (RQ) was developed by Knott (2008) as discussed above and is being vigorously tested in the literature (Cooper et al., 2015; Cooper, Knott, & Yang, 2019; Huang & Irawan, 2017; Knott & Vieregger, 2020). RQ is defined as, “…the firm-specific output elasticity of R&D” (Cooper et al., 2015; Knott, 2008).

RQ supports models that conceptualize technological change originating from profit-seeking agents endogenous to the firm (Romer 1990, Thompson 1996, and Lentz and Mortensen 2008). This also makes RQ a reasonable empirical proxy for theoretical innovation constructs. Thus, RQ can be interpreted as a firm’s ability to generate revenue from R&D expenditures (Cooper et al., 2019). So, firms can benefit from a high RQ in one of two ways. A firm can generate a large number of innovations and reasonably exploit them, or they can generate a smaller set of innovations but be extremely effective at exploiting them.
When RQ is empirically tested against the patent-based measures discussed previously, the correlation between RQ, R&D input and patent-based outputs are close to zero. Additional research shows that using efficiency-based measures such as patents or citations scaled by R&D (Hirshleifer, Hsu, and Li 2013) also generate correlations close to zero. This opens the door for the supposition that data captured in the RQ measure might supply information beyond that captured by the traditional measures discussed. RQ also address the universality and uniformity concerns discussed previously by allowing any firm conducting R&D to be included in the measure (whether or not they file for a patent) and they are unitless measures (allowing for a uniform measure across firms).

**Conceptual Framework and Hypothesis Development**

Our examination of the relationship between innovation and firm performance is best understood through the broad lens of the resource-based view of the firm and how allocation of

![Conceptual Model](image-url)
said resources impact firm performance. The conceptual model for this study is presented in Figure 1.

Resource-Based View

The RBV explains a firm’s superior performance through its use of specific resources owned by the firm (Barney, 1991; Peteraf, 1993; Wernerfelt, 1984). At its very core, the level of innovation a company pursues is a question of how it chooses to allocate their resources. A resource is defined as, “assets, organizational processes, capabilities, firm attributes, information, knowledge, etc. controlled by a firm that enable the firm to conceive of and implement strategies that improve its efficiency and effectiveness” (Barney, 1991). RBV’s central tenets involves pathways (organizational processes and knowledge management) and heterogeneity (VRIN framework of resources). The underlying idea driving this resource-based approach is how firms utilize their resources in order to drive performance in a dynamically competitive environment (Collis and Montgomery, 1995). The goal being to exploit firm resources to achieve competitive advantage in the marketplace and to create a stream of above average returns creating superior value to the firm. This is primarily accomplished through the RBV framework of a firm having assets (or capabilities) that are valuable, rare, inimitable, and nonsubstitutable (Barney, 1991). Given this primarily internal focus, the resource-based view states that firms should focus on building a unique resource base that is immobile and heterogeneous thus making it difficult, if not impossible, to replicate. This, in turn, allows the firm to exploit any opportunities while mitigating external threats and thus achieving competitive advantage.

A firm’s ability to achieve sustainable competitive advantage relies on the ability of an organization to quickly reconfigure and constantly renew supplies of valuable and idiosyncratic
resources to foster innovation (Eisenhardt & Martin 2000; Teece, Pisano, Shuen 1997). Given the focus of this study is to unravel the innovation – firm performance linkage, RBV is used because the literature shows it to be an effective lens for analyzing innovation and how it relates to firm performance (Damanpour, Walker, Avellaneda 2009; Galende & de la Fuente 2003).

Given that the research questions addressed in this study focus on issues involving governance structure and characteristics of leadership, the focal variable of innovation productivity will be measured using RQ. RQ is a better indicator of firm innovation because it captures the productivity of the R&D department. That is RQ can help firms better understand their R&D spend and exploit their capabilities to produce innovations which lead to competitive advantage and higher revenues. RQ is an appropriate measure in this paper for two reasons. Studies testing governance and innovation assume R&D is carried out to maximize firm value. Additionally, governance studies assume that CEO’s affect innovation levels. Given the focal IV in this study is the RQ measure and several moderators will involve governance variables, the RQ measure fits what is being tested in this paper. The underlying assumption of innovation and governance related research that firms choose to engage in R&D activities to maximize firm value aligns with the studies that CEO’s affect the level and success of innovation. Having presented evidence in support of RQ as an alternative measure of innovation, it would be expected that RQ would have a positive impact on firm performance.

\[ H_1: \text{Innovation capability will have a positive effect on firm performance.} \]

**CEO and TMT pay gap**

The most direct and successful means of affecting CEO behavior is through incentive compensation. CEO compensation packages have long been a point of contention in the management literature and are thought by some researchers to dilute value from the firm and
shareholders (Calian, 2002; Eisinger, 2006). One aspect of CEO compensation that has garnered recent attention is the CEO - TMT pay gap. The CEO pay gap is defined as the difference between the CEO’s compensation and the average compensation for the rest of the top management team (Henderson & Frederickson, 2001). Research has shown that TMT compensation is as little as 40% of that of the CEO (Conyon, 2006, p. 28), while CEO compensation is increasing at a faster rate than that of other executives (Useem, 2003). The pay gap between CEO’s and their TMTs could be thought of as the reward expected by non-CEO’s were they promoted to CEO. Prior research examining the CEO pay gap has resulted in less than consistent results (Carpenter & Sanders, 2004; Eriksson, 1999; Henderson and Frederickson, 2001). Traditional economic theory falls short of explaining the pay gap since it argues that pay levels are determined by marginal output. Tournament theory offers an alternative explanation for why pay gaps in corporate compensation systems are useful and seem to work.

Much of the research investigating executive compensation applies agency theory which posits that rewarding managers based on decision outcomes is the best shot at resolving the inevitable conflict of interest between managers and owners (Brenes, Madrigal, & Requena 2011). Depending on how performance incentives are structured can lead to manipulation of performance measures in favor of short term goals versus longer term strategic goals.

Tournament theory offers a complementary perspective. Tournament theory (Lazear & Rosen, 1981; Rosen 1986) is an economic theory based on competition as a means of addressing the classic principle-agent problem mentioned above. Tournament theory asserts that employers develop compensation packages for CEO’s and top executives based on an internal ordinal ranking versus absolute performance. This is much simpler, so costs associated with monitoring are reduced and it incentivizes competition among the TMT while also discouraging shirking.
Henderson and Fredrickson (2001) argued that the results from such a tournament would produce optimal allocation of social resources and improve firm performance. Thus, competitors for promotions become contestants in a single elimination contest where the promotion (gap) is the prize. This compensation method ties aspects of a CEO’s compensation to the long-term outcome of the firm, and it is thought that this type of compensation will keep CEOs from trading short-term gains for more lucrative long-term incentives.

According to tournament theory, as long as monitoring is reliable and cheap, paying agents according to their marginal output keeps incentives aligned and promotions are easily determined based on outputs. As monitoring becomes more difficult and problematic, agents are more likely to shirk, and promotion decisions become much more difficult. Due to the lack of clear measures of agent output, principals may implement tournaments where 1) pay increases as rank increases, 2) the size of the pay gap between ranks increase hierarchically, and 3) the gap between the CEO and next highest ranking executive is very large. Large pay gaps provide strong incentives, which lead to greater effort and finally to improved firm performance. As monitoring becomes more difficult, the pay characteristics just described get more aggressive. Thus, the gap between the CEO and their TMT provides stronger incentives for non-CEO executives to compete for the tournament prize (CEO position and higher pay). Given the link between CEO’s and innovation, I expect the CEO pay gap to have a positive moderating effect on the relationship between innovation and firm value.

**H2: The relationship between research productivity and firm performance will be positively moderated by the CEO/TMT pay gap such that the relationship is stronger for larger pay gaps.**

*Munificence*
Starbuck (1976) conceptualized munificence as the extent to which the environment can support sustained growth. Munificence is later defined by Boyd (1990) as the relative level of resources (abundance or scarcity) available in an environment and measured by industry level growth. This could include financial capital and/or growing markets that would support firm growth and performance (Castrogiovanni, 1991). A munificent environment would be one marked by external growth and increased opportunities for increasing financial revenues. These opportunities might take the form of lower taxes, an abundant and knowledgeable work force, fast growth markets, or a general economic upswing (Decarolis & Deeds, 1999) Firms competing in high munificence environments tend to be more confident in developing long-term strategies (Barney, 1991) including a more aggressive stance towards innovation. Munificent environments also allow firms the opportunity to acquire additional resources which can be converted into additional capabilities (McEvily & Zaheer, 1999) creating an upward spiral that would support innovation activities. Research supports the fact that munificent environments interact with strategy to effect firm performance (McArthur & Nystrom, 1991), thus lending credence to our contention that firms invested in innovation should see a positive interaction between munificent environments and R&D efficiency on firm performance.

Low munificent environments are characterized by a lack of resources, stagnant or falling demand and numerous external threats. When resources become scarce the moderating effects of the environment negatively impact the firm resulting in increased competition (Dess & Beard, 1984; Hambrick, 1983; Porter, 1980), decreased profitability and increased slack (Beard & Dess, 1981; Child, 1972), as well as intraorganizational changes (Koberg, 1987). For example, in high tech markets, resources typically take the form of knowledge. Given the high level of competition among high-tech firms it would be expected that the environment would be less
munificent. According to Khandwalla (1973), these types of non-munificent environments require greater analytical effort to assess threats and a scarcity of resources leads firms to avoid excessive risk taking and reduce innovation (Miller & Friesen 1983). Low munificence environments would be driven by uncertainty manifested through the competitive actions of other firms, areas of competitive overlap, and legal, political, and economic constraints. This would create a high level of uncertainty which is associated with higher levels of innovation and risk-taking behaviors (Pierce & Delbecq, 1977). Given this discussion of environmental munificence it is believed that its interaction with innovation will weaken the positive relationship with firm performance.

H3: The relationship between research productivity and firm value will be negatively moderated such that the relationship is weakened at lower levels of munificence.

Dynamism

Dynamism is a measure of stability and represents the rate of change in an environment as well as the predictability of those changes. Measures of environmental stability/instability identified in organization theory and business policy research are turnover, absence of patterns and unpredictability (Dess and Beard, 1984). Dynamism is defined as, “the level of turbulence or instability facing an environment and measured by variability in growth rates” (Boyd, 1990). Several empirical studies show that the greater the uncertainty in the environment the greater the environmental dynamism (Duncan, 1972; Milliken, 1987, 1990; Tung 1979) and thus the greater the need for firms to innovate to survive. Forces comprising dynamism include opportunities for growth, changes in technology and their diffusion, rates of innovation, and amount of R&D activity in the industry. Previous research has argued that the rate of environmental change should be differentiated from unpredictability within the environment (Miles, Snow, & Pfeffer,
1974; Jurkovich, 1974). As a dimension of environmental impact, dynamism is a measure of the volatility in the environment. Following Aldrich’s idea of turbulence which focused on interconnectedness between environmental elements, Pfeffer and Selancik (1978, p.68) contended that high levels of turbulence (dynamism) would result in more uncertain and unstable environments where, “changes can come from anywhere without notice and produce consequences unanticipated by those initiating the changes and those experiencing the consequences.” Consequently, as environmental dynamism increases it reduces visibility to knowledge needed to make crucial decisions, thus reducing stability and predictability of relations with other firms. The logical inference being that the greater the environmental dynamism the more difficult it is for leadership to make the right decisions because of less reliable information. Thus:

\[ H_4: \text{The relationship between research productivity and firm value will be negatively moderated such that the relationship is weakened at higher levels of dynamism.} \]

Table 1 below offers an overview of all measures and associated data sources.
Table 2  Summary of Measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Operationalization</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firm Performance</td>
<td>Tobin’s Q (Chung &amp; Pruitt, 1994)</td>
<td>Derived from COMPUSTAT</td>
</tr>
<tr>
<td>Innovation Productivity</td>
<td>Research Quotient (RQ)</td>
<td>RQ Database (WRDS)</td>
</tr>
<tr>
<td>CEO/TMT Pay Gap</td>
<td>Natural log of CEO total compensation minus the average of compensation of top 5 listed executives</td>
<td>ExecuComp</td>
</tr>
<tr>
<td>Industry Munificence</td>
<td>Industry sales regressed on time over 5-year rolling windows and the slope of the regression coefficient is divided by the mean of industry sales (lagged 1 year)</td>
<td>COMPUSTAT</td>
</tr>
<tr>
<td>Industry Dynamism</td>
<td>Industry sales regressed on time over 5-year rolling windows. Standard error of the regression coefficient is divided by the mean of industry sales (lagged 1 year)</td>
<td>COMPUSTAT</td>
</tr>
<tr>
<td>Firm Size</td>
<td>Logarithm of total sales (lagged 1 year)</td>
<td>COMPUSTAT</td>
</tr>
<tr>
<td>Slack</td>
<td>Current Ratio: Current Assets/ Current Liabilities</td>
<td>COMPUSTAT</td>
</tr>
<tr>
<td>ROA</td>
<td>Operating Income Before Depreciation as a fraction of average Total Assets based on most recent two periods</td>
<td>COMPUSTAT</td>
</tr>
<tr>
<td>Industry Concentration</td>
<td>HHI: square root of market share for all firms in 2-digit SIC (lagged 1 year)</td>
<td>COMPUSTAT</td>
</tr>
<tr>
<td>Market Share</td>
<td>Firm sales revenue divided by total industry sales, based on four-digit industry SIC codes</td>
<td>COMPUSTAT</td>
</tr>
</tbody>
</table>

**Empirical Context and Methodology**

*Data and Sample*

The primary data for this study comes from three sources within the Wharton Research Data Services (WRDS): COMPUSTAT North American Annual database, Execucomp and the WRDS RQ database. The COMPUSTAT database provided firms’ financial information; Execucomp provided CEO and TMT salary and compensation information; and the WRDS RQ database provided firms research quotient (RQ). As the RQ database is only available from 1990
to 2015 this will be the analysis range. All three data sources were merged in Stata using the
gvkey-year that identifies each firm by year.

**Measures**

*Dependent Variable*

Performance outcome indicators in the past have typically been accounting based
measures such as profit and sales revenue or market share. This study is attempting to understand
the relationship between R&D output and firm performance, and it is our position that the typical
accounting based measures are insufficient by themselves to fully explain firm performance.
How firm performance is measured is largely determined by the questions being asked. Using a
financial market perspective, Tobin’s Q has become one of the most utilized performance
measures in marketing because it not only incorporates the past events concerning the firm but
also future tendencies, as expressed by market value of stock shares, and potential success of
new products and projects (Sauaia & Castro, 2002).

Corporate finance researchers use Tobin’s Q as a proxy for a firms’ investment
opportunities. The value and asset pricing literature uses the Q-ratio—the ratio between the
market’s valuation of the financial book value and the cost of replacing assets both tangible and
intangible—has been used to explain a wide variety of phenomena (Cockburn and Griliches,
1988; Megna and Klock, 1993). The Q ratio’s appropriateness depends on the theoretical
assumptions made. As a firm level variable, Tobin’s Q explains tangible and intangible
investments equally well, and it explains total investment even better (Peters and Taylor, 2016).
In this model, the dependent variable utilized is Tobin’s Q, because it is forward looking and
represents the judgement of the financial market on a company’s value and can be used to
compare across industries because it is unaffected by accounting methods (Chakravarthy 1986). Tobin’s q was calculated using Chung and Pruitt’s (1994) proposed method.

*Independent Variable*

Theoretical support is offered for a new measure of R&D productivity (RQ) that matches up well with empirical predictions of firm R&D investment, firm value and growth predicted by endogenous growth theory (Romer 1990; Thompson 1996; Lentz & Mortensen 2008). The RQ measure is presented as a complementary measure of R&D outcomes in order to address some of the weaknesses of current measures such as patents. Absence of a reliable and consistent understanding of the innovation – firm performance relationship in the existing literature leads to consideration of several moderating variables of the relationship between innovation (RQ) and financial performance. In this instance the value generated by a firm’s output elasticity of R&D or RQ.

RQ (γ in the equation below) is embedded in a firm’s production function so it acts to empirically capture a continuing input of knowledge as the output elasticity of R&D (Cooper et al., 2015).

$$Y = A_i, K_{i,t}^\alpha L_{i,t}^\beta R_{i,t-1}^{\gamma} S_{i,t-1}^{\delta} D_{i,t}^{\phi} e_{i,t}$$

Where Y is output, A is a firm fixed effect, K is capital, L is labor, R is R&D (lagged), S is spillover (lagged) and D is advertising. So RQ represents the percentage increase in revenues from a 1% increase in R&D, when other inputs and elasticities are held constant (Cooper et al., 2015). This makes RQ the firm level equivalent of economists most common means of measuring industry-wide returns to R&D (Hall 1993, Hall, Mairesse, & Mohnen 2010). Knott (2008) proposed that part of the problem with previous empirical models attempting to understand returns to R&D was the empirical models could not account for heterogeneity in firm
R&D elasticities. At the firm level, these measures recognize that there is a tremendous heterogeneity even among firms within the same industry. The actual calculation for the RQ measure was derived from the production equation above but using a random coefficients (RC) model which allows for heterogeneity in output elasticities (for a more complete explanation see Cooper, Knott, & Yang 2015 Appendix A). A random coefficients model (Longford 1993) is utilized because it represents a general functional form model with non-fixed coefficients possibly correlated with the error terms. The coefficients of RC models have two parts: a direct effect of the focal variable and a random component that acts as a proxy for omitted variables. The RC model is below:

\[
\ln Y_{it} = (\beta_0 + \beta_{0i}) + (\beta_1 + \beta_{1i})\ln K_{it} + (\beta_2 + \beta_{2i})\ln L_{it} + (\beta_3 + \beta_{3i})\ln R_{i,t-1} + (\beta_4 + \beta_{4i})
\]

\[
\ln S_{i,t-1} + (\beta_5 + \beta_{5i})\ln D_{it} + \varepsilon_{it},
\]

where \(\beta_{-} + \beta_{-i}\) represent the direct effect and firm specific error respectively, \(Y\) is revenues, \(K\) is capital, \(L\) is labor, \(R\) is R&D investment, \(S\) is innovative spillovers, and \(D\) is advertising. RQ is the sum of \(\beta_3\) and \(\beta_{3i}\) (Knott & Vieregger, 2020) and corresponds to the \(\gamma\) in the production equation above. The RQ values for this study were taken from the COMPUSTAT database and not calculated by the authors. Values of all focal variables were mean centered due to lack of a real zero value for RQ and to help with multicollinearity issues.

**Moderators**

Following Henderson & Fredrickson (2001) the CEO – TMT pay gap was computed as the ratio of the CEO’s total compensation to the average total compensation for the next five highest paid TMT members. Total compensation is reported in ExecuComp as TDC1 and includes salary, bonus, other annual awards, total value of restricted stock granted, total value of
stock options granted, long-term incentive payouts and other compensation. Compensation data was then matched to firms contained in the RQ database.

Industry dynamism refers to the extent of unpredictable change in an organization’s environment. Dynamism was measured by taking the standard error from a rolling five-year regression of industry sales on time, standardized by mean industry sales for that year (Raassens 2011). Munificence, in general, refers to an environment’s ability to support sustained growth within organizations (Aldrich 1979). Earlier research suggests firms in low-munificent (hostile) environments emphasize conservation of resources and are less likely to engage in innovation (Miller & Friesen, 1983). Munificence was measured as the beta coefficient from the rolling five-year regression of industry sales on time, normalized by average industry sales for that year.

**Control Variables**

It is important to control for firm and industry specific variables because of their possible impact on a market valuation measure like Tobin’s Q. Larger firms tend towards more stable returns so firm size was controlled for and measured as the natural logarithm of total assets and current assets. Market share and ROA were also controlled for since they can also impact firm performance. An overall industry competitiveness measure, the Herfindahl – Hirschman Index (HHI), was included and is calculated by using the squared market shares of firms within an industry (2-digit SIC).

The full model, including all interaction effects is specified as follows:

\[
\text{Firm Performance} = \beta_0 + \beta_1 \text{RQ} + \beta_2 \text{Pay Gap} \\
+ \beta_3 \text{Munificence} + \beta_4 \text{Dynamism} \\
+ \beta_5 \text{RQ} \times \text{Pay Gap} \\
+ \beta_6 \text{RQ} \times \text{Munificence} \\
+ \beta_7 \text{RQ} \times \text{Dynamism} \\
+ \beta_8 \text{Firm Size(Assets)} + \beta_9 \text{Total Assets} + \beta_{10} \text{ROA} + \beta_{11} \text{HHI} + \beta_{12} \text{Market Share} + \beta_{13} \text{Year Dummy} + \beta_{14} \text{Industry Dummy (SIC-2 digit)} + \varepsilon_i
\]
Descriptive statistics are presented in Table 3. Several variables initially demonstrated possible outliers and the data was winsorized at the top and bottom 1%. The data presented in Table 3 is after winsorization. An examination of the correlation table (Table 4) indicates the correlation between variables is less than 0.5 and fulfills the Abdullah (2006) required values of less than 0.85.
## Table 3

### Descriptive Statistics and Correlation Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Firm Performance</td>
<td>1.500</td>
<td>2.342</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2. Innovation Capability</td>
<td>0.112</td>
<td>0.129</td>
<td>-0.008</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>3. Pay Gap</td>
<td>5.971</td>
<td>0.751</td>
<td>-0.093</td>
<td>0.076</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>4. Munificence</td>
<td>6.286</td>
<td>25.859</td>
<td>0.094</td>
<td>0.122</td>
<td>0.015</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Dynamism</td>
<td>4.431</td>
<td>0.085</td>
<td>-0.053</td>
<td>0.108</td>
<td>-0.034</td>
<td>0.056</td>
<td>1.00</td>
<td></td>
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<tr>
<td>6. Firm Size</td>
<td>6.180</td>
<td>2.744</td>
<td>-0.146</td>
<td>0.056</td>
<td>0.530</td>
<td>0.030</td>
<td>-0.038</td>
<td>1.00</td>
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<tr>
<td>7. Slack</td>
<td>3.206</td>
<td>3.624</td>
<td>0.057</td>
<td>0.013</td>
<td>-0.264</td>
<td>-0.004</td>
<td>0.041</td>
<td>-0.354</td>
<td>1.00</td>
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<tr>
<td>8. Ind. Concentration</td>
<td>0.047</td>
<td>0.037</td>
<td>-0.106</td>
<td>-0.042</td>
<td>0.090</td>
<td>-0.042</td>
<td>-0.023</td>
<td>0.053</td>
<td>-0.100</td>
<td>1.00</td>
<td></td>
<td></td>
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<tr>
<td>9. Market Share</td>
<td>0.010</td>
<td>0.034</td>
<td>-0.060</td>
<td>0.027</td>
<td>0.236</td>
<td>-0.005</td>
<td>-0.011</td>
<td>0.433</td>
<td>-0.183</td>
<td>0.465</td>
<td>1.00</td>
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</tr>
<tr>
<td>10. ROA</td>
<td>-0.255</td>
<td>6.215</td>
<td>0.163</td>
<td>0.057</td>
<td>0.084</td>
<td>-0.012</td>
<td>0.006</td>
<td>0.218</td>
<td>-0.061</td>
<td>0.045</td>
<td>0.091</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Total N = 2947
**Analysis and Results**

Given the unbalanced nature of the panel data and the amount of missing data for some of the variables, the final sample size for the regression model was 2883. The panel data analysis was performed using the STATA program *xtreg*, specifically GLS random effects model. The *xtreg* command in STATA 16 was used since the data was nested by firm and year and “gvkey” was used as the panel variable. In support of this decision, the final model (Model 3) was significant (Wald Chi-Square \( (57) = 363.64, p < .001 \)) with an r-squared of .17.

Table 3 presents random effects GLS results for tests of the hypotheses concerning RQ and Tobin’s q. All models were significant according to the Wald \( \chi^2 \) test. Model 1 includes only control variables. Model 2 tests the main effects of RQ on Tobin’s q (H1) as well as the main effects of the hypothesized moderators and approaches significance (\( p = .08 \)). Model 3 tests the remaining hypotheses and includes all proposed interactions (H2-H5). Hypothesis testing is based on Model 3. The direct effect of the RQ measure becomes significant in this final model thus supporting H1 (\( \beta = 1.405, z = 2.94, p < .01 \)). In testing the moderation effect of CEO/TMT
<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 Controls Only</th>
<th>Model 2 Main Effects RQ</th>
<th>Model 3 Moderators and Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
</tr>
<tr>
<td>Firm Size</td>
<td>-.228*** (.031)</td>
<td>-.228*** (.031)</td>
<td>-.239*** (.032)</td>
</tr>
<tr>
<td>Current Assets</td>
<td>-.025* (.011)</td>
<td>-.025* (.011)</td>
<td>-.020 (.011)</td>
</tr>
<tr>
<td>Leverage</td>
<td>-.269 (.171)</td>
<td>-.251 (.171)</td>
<td>-.148 (.172)</td>
</tr>
<tr>
<td>ROA (lagged)</td>
<td>.710*** (.158)</td>
<td>.694*** (.158)</td>
<td>.602*** (.160)</td>
</tr>
<tr>
<td>HHI</td>
<td>2.384 (2.257)</td>
<td>2.311 (2.256)</td>
<td>1.704 (2.250)</td>
</tr>
<tr>
<td>Market Share</td>
<td>2.621 (1.675)</td>
<td>2.522 (1.676)</td>
<td>2.138 (1.714)</td>
</tr>
<tr>
<td>RQ (H1)</td>
<td>.647* (.399)</td>
<td></td>
<td>1.128*** (.395)</td>
</tr>
<tr>
<td>CEO/TMT Pay Gap</td>
<td></td>
<td>.045 (.034)</td>
<td></td>
</tr>
<tr>
<td>Munificence</td>
<td></td>
<td>-.001 (.001)</td>
<td></td>
</tr>
<tr>
<td>Dynamism</td>
<td></td>
<td>-1.816*** (.168)</td>
<td></td>
</tr>
<tr>
<td>RQ X Pay Gap (H2)</td>
<td></td>
<td>.659* (.313)</td>
<td></td>
</tr>
<tr>
<td>RQ X Munificence (H3)</td>
<td></td>
<td>-.025*** (.008)</td>
<td></td>
</tr>
<tr>
<td>RQ X Dynamism (H4)</td>
<td></td>
<td>-10.353*** (2.340)</td>
<td></td>
</tr>
<tr>
<td>Wald Chi Square</td>
<td>337.21***</td>
<td>339.88***</td>
<td>389.34***</td>
</tr>
<tr>
<td>R-Square - within</td>
<td>.08</td>
<td>.08</td>
<td>.10</td>
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<tr>
<td>- between</td>
<td>.17</td>
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<td>- overall</td>
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<td>.15</td>
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</table>

Note: N = 2947 *p < .10, **p < .05, ***p < .001
pay gap on the relationship between RQ and firm performance, results indicate a positive and significant estimate ($\beta = .747, z = 2.25, p < .01$), indicating that the pay gap between CEO’s and their TMT’s serves a purpose when it comes to innovation outcomes and thus supporting H2. H3 posits that environmental munificence will negatively interact with innovation output. These results demonstrate a significant negative moderating effect thus offering support for H3 ($\beta = -.032, z = -3.73, p < .001$). Finally, H4 examined the effect environmental dynamism might have on the innovation firm performance link. The hypothesis was that environmental dynamism would negatively moderate the relationship between innovation and firm performance. In line with that hypothesis, dynamism exhibited a significantly negative estimate ($\beta = -10.74, z = -4.19, p < .001$) thus offering support for H4.

**Discussion**

Innovation is not just about creativity and generating new ideas, it is a complex, dynamic process of allocating resources (people, assets, management) to spur future growth of the firm; a process that is still the subject of much study in the academic arena. The need for innovation comes from the constantly evolving landscape of competitive markets. Threats and competition can come from anywhere at any time (i.e., taxi industry and Uber; or Elon Musk and the car industry) and firms must be ready to react. In order to react properly, the nature of the relationship between innovation and improved performance must continue to be explored and understood so that the best competitive decisions can be made so firms remain competitive.

This study contributes to the growing literature examining possible influences on the relationship between R&D, innovation, and firm performance. Previous research trying to understand innovation outcomes that relied on patent or citation data offered an incomplete picture (lacking universality and uniformity) are complemented by using the RQ measure to
offer a more complete picture of innovation and its relationships with firm performance. An additional unique aspect of this study is that the RQ measure was used as a predictor variable which we believe to be a first as it has been used in previous literature as a moderator and/or an outcome variable. The results obtained in this study would seem to support using RQ has a predictor to be valid and when combined with other independent variables should help to further unravel the innovation – firm performance relationship. Innovation research using patent data and RQ together should give stakeholders a much more complete view of how innovation activity is showing up in firm performance measures.

Using a sample of publicly traded firms, this study investigates several possible contextual variables and how their moderating effect might impact a firm’s ability to translate innovation ability into increased firm performance. Results of the cross-sectional regression demonstrate the impact (positive and negative) of various firm and industry level variables that reinforce (impede) the direct effect of RQ and firm performance.

The CEO/TMT pay gap demonstrated a positive impact on the innovation – firm performance relationship contributing to the CEO and TMT area in the strategy literature. The mixed results in the existing literature would seem to indicate that a certain level of disparity between the CEO and the TMT is a good thing while at a certain point the level of disparity begins to damage the performance of the firm. The approach taken in this paper applied tournament theory to explain the difference in compensation between the CEO and the TMT and we found support for the pay gap augmenting the relationship between innovation and firm performance. Investment in R&D and a firm’s decision to pursue innovative strategies are greatly influenced by the CEO so this finding was in line with our prediction.
Environmental jolts can surprise organizations and completely change the expected outcomes of a firm’s strategic actions. The level of munificence plays a key role in how firms acquire and allocate available resources such as materials, capital, and labor. Munificent environments allow firms to engage slack resources towards strategic goals thus improving firm performance. When munificence is low and resources are harder to come by, firms adjust their focus towards dealing with competitive pressures and tend to focus on intraorganizational changes. In our data sample over half the observations (51.35%) showed a negative value for the munificence measure and while the mean was positive (6.29) it was low which seems to indicate low levels of munificence in our sample. This reconciles with the negative test coefficient in our regression model and demonstrates that the relationship between RQ and firm innovation is restrained when munificence is at lower levels.

Environmental dynamism is concerned with environmental instability, the rate of change and the unpredictability of environmental factors. Dynamism within an industry can originate from many areas including technological, economic, political, the market, and things peculiar to specific industries. Regardless of where it originates, as dynamism increases, information needed to make strategic decisions will become more occluded and firms will be making more decisions with more uncertainty. It was our contention that dynamism would have a mitigating effect on the positive relationship between innovation and firm performance and that was exactly what we found.

Overall, this study sought to examine the relationship between a new measure of innovation (RQ) and a forward looking measure of firm performance considering a firm level moderator and as well as the moderating effect of environmental variables. The results were all in line with what we expected, and they demonstrated several things. First, the pay gap between
CEO’s and their TMTs has a significant impact on the relationship between innovation and firm performance. Second, environmental variables clearly impact firm performance and innovation. Lastly, this research would seem to strongly support the contention that the relationship between innovation and firm performance is not a direct one but is highly dependent on contextual factors both at the firm and industry levels.

The research also contributes to the ongoing discussion of marketing position in the upper echelons of the firm. Marketers are arguably the agents within the firm that are the closest to the consumer and thus in a position to understand the needs and wants that exist in the market. This type of research which addresses the innovation – firm performance relations is vital for marketers to not only understand but have a voice in shaping.

**Limitations and Future Research**

The sample for this study only included publicly traded firms which is a limitation when exploring the RQ measure as it is a universal measure that relies solely on financial data. It would also be of interest to see if RQ holds the same for non-U.S. based firms. There are several other factors not examined in this study, that impact our understanding of innovation and firm financial performance. Compared to previous measures of R&D performance (patents, citations etc.) this study demonstrates the usefulness of the RQ measure and its ability to shine additional light on the innovation payoff question. RQ does have some inherent limitation which is common to estimates of output elasticities, is that the inputs of the production function are themselves endogenously determined by the elasticities (Knott & Vieregger, 2020). Firms with higher RQ scores have higher levels of R&D meaning R&D investment should increase RQ. This simultaneity problem is an area of ongoing research where production functions are used in a measure.
Future researchers could extend this research further by examining the impact of different types of innovations (radical innovation versus incremental innovation) and how the market reacts to these announcements. Another perspective might be to examine the relationship in the context of innovation by acquisition (mergers, acquisitions, alliances, and joint ventures) versus organic endogenous growth. We believe that the RQ measure would prove very valuable for examining the endogenous growth question.

In addition to the pay gap results explored herein we believe this to be just the tip of the iceberg and that there are other CEO and TMT characteristics that could contribute to this area of study. It has been established that the CEO plays a significant role in how or whether a firm determines to pursue innovation. CEO characteristics such as narcissism, tenure, functional experience, insider/outsider status, duality, and total compensation package significantly impact both ends of the innovation – firm performance relationship. Specifically, these CEO characteristics would prove very interesting in how they influence the RQ measure introduced in this study. Composition of the TMT (number, gender, race) and its power dynamic with the CEO would also be an area of future interest as well as the presence or absence of a chief innovation officer (CIO) or chief marketing officer (CMO).

We hope this study will spur further use of the RQ measure as an additional tool for understanding innovation and how that translates to a firm’s bottom line.
III. Product-Market Strategy Influence on Innovation Productivity

Michael S. Houston

University of Memphis
Abstract

There is no question that innovation is important, not only for firm growth but for overall economic growth. The literature is replete with studies that examine the drivers of innovation, but very few examine product-market choice as one of those drivers. This study utilizes data generated from high-technology software manufacturers as well as data from the Hoberg-Phillips Data Library to examine the relationship between product-market strategies (differentiation and vertically integrated product line) and innovation productivity. Our results offer support that product-market strategy can have a bolstering effect (vertically integrated product line) or a suppressing effect (differentiation). Product market density and strategic execution were found to have positive effects on the relationship.
Introduction

Unforeseen challenges are ubiquitous in today’s business landscape. Innovation can help firms navigate the tempestuous realities of today’s business world. The term innovation is pervasive in today’s business lexicon, yet many businesses struggle to define what innovation means which leads to incorrect decision making by individuals and firms offering a possible reason for why many organizations still find innovation elusive (Kurato, Covin, & Hornsby, 2014). The term innovation has also found its way into an organization’s vision and mission statements, politicians use it in their speeches, and it has found its way into the upper echelons of management with many firms now having a Chief Innovation Officer. Centers of innovation are also appearing on many college campuses. Innovation is essential for sustainable growth and economic development. “Innovation is critically important in contemporary economies. A key driver of the improvement in consumers' living standards is the growth and success of firms, and the wealth of nations. Investment in research and development (R&D) is essential for firms and nations to produce innovations and compete for the future”. (Tellis, Eisingerich, Chandy, & Prabhu, 2008). Firms that operate with a focus on innovation are more adaptable and can better respond to change. Innovation also fosters growth for the firm and overall economic growth. Perhaps most importantly innovation allows companies to distinguish themselves from their competition.

The extant literature regarding what drives innovation is wide-ranging. These determinants or drivers of innovation are a collection of factors that affect a firm’s innovation rate or productivity (Duchesneau, Cohn, and Dutton, 1980). These drivers are what pushes a firm towards innovation activity and enables firms to address customer wants and maintain or gain a competitive advantage. Firm size has long been thought to be an essential driver of innovation (Knott &
Vieregger, 2015; Romero & Martinez-Roman, 2012). Additional drivers of innovation from the literature include finance and the economy (e.g., Bozic & Rajh, 2016; Lecerf, 2012), technological capabilities (e.g., Berkhout, Hartmann, & Trott, 2010; Qian & Li, 2003), institutional support (e.g., Volchek, Jantunen, & Saarenketo, 2013), consumer relationship (e.g., Laforet, 2011), organizational culture (e.g., Buckler, 1997; Menzel, Aaltio, & Ulijn, 2007), management system (e.g., Burgelman, 2015), learning capacity (e.g., Aragon-Correa, 2007; Calantone, Cavusgil, & Zhao, 2002), competitive advantages (e.g., Barney, 1991; Chen, 2009), and market orientation (e.g., Jaworski & Kohli, 1993; Varadarajan & Jayachandran, 1999). However, very little is known about how product-market strategy impacts innovation productivity.

Product-market strategy is one of the most essential elements of a firm’s overall strategy and focuses primarily on how firms position themselves and chose to compete in their targeted market spaces (Aaker, 1999; Day & Wensley, 1988). Product-market strategy is especially important to marketing strategy researchers since it is at this level of strategy development that marketers have the most input and influence (Varadarajan and Jayachandran, 1999). While it is apparent that product-market strategy plays an important role in business growth, what is much less apparent is which type of product-market strategy has the greatest effect on innovation and thus growth. The answer to this question is crucial for managers. Decision makers are responsible for making difficult decisions concerning allocation of scarce resources, including those resource investments in innovation activities. Regardless of the innovation type (radical, incremental, proactive, reactive) having some idea of the expected product-market strategy (differentiation or vertical integration of the product-line) should help managers tremendously when making those resource allocation decisions. Differentiation is the designing of meaningful
differences to distinguish one firm’s offerings from a competitor’s (Kotler & Armstrong, 2003). An advantage of a differentiation strategy would be achieved through quality products and an emphasis on innovation. Firms with vertically integrated product lines tend to exhibit a strong link between product-market strategy and innovation output (Fresard, Hoberg, & Phillips, 2015).

Based on extensive archival research, a unique dataset of 309 firm-year observations comprised of firms identified by Garter Inc as competing in the Business Applications packaged software sector was matched with data from the Hoberg-Phillips Data Library, the RQ database from WRDS, and financial data from COMPUSTAT. A random effects regression model was used to examine how product-market strategy (differentiation or vertical integration of the product line) would influence the direction and magnitude of innovation productivity. Study findings proved to be mixed (negative for differentiation and positive for vertical integration), however, mitigating support was found based on how well firms executed their strategy (differentiation and vertical integration) and product-market competitive density (vertical integration) of the specific sectors.

This study contributes to the literature in three key ways. First, this study is one of the few that examines the direct links between product-market strategy and outcomes of innovation. In doing so, this study will contribute to our better understanding of the drivers of innovation and how marketing strategy can influence one of the keys to overall business success. Our results demonstrate that the approach to product-market strategy chosen by the firm can have a significant impact (impeded or stimulated) on the productivity of innovation activities. This is useful to managers who must make decisions concerning allocation of resources where gains may not be seen for some time. Our results indicate that firms pursuing a differentiation product-market strategy might not see productivity from innovation in the short-term and should position
resources so that any possible gains from innovation activity can be realized. Support is also offered to support the contention that a vertically integrated product line strategy would bolster innovative productivity. Second, this study offers additional insight into the determinants of innovation beyond the ones generally seen in the literature (i.e., firm size). The addition of which product-market strategy a firm chooses adds another perspective to understanding innovation productivity. Finally, this study contributes to the literature by utilizing the new text-based network industry classifications (TNIC) developed by Hoberg and Phillips. These measures based on web-crawling and text parsing algorithms parallel the idea of a social network.

The remainder of the paper is organized as follows. First, we outline our conceptual and theoretical framework. Then, we develop a set of hypotheses explaining how product-market strategy, strategic execution, and product-market density influence the direction and magnitude of innovation productivity. We then proceed with the methodology and results and conclude with implications for theory and practice and the study’s limitations.

**Conceptual Development**

We examine the relationship between product-market strategy and innovation productivity using the lens of resource-advantage (R-A) theory of competition (Hunt and Morgan 1995, 1996, 1997). R-A theory combines heterogeneous demand theory (Alderson, 1957, 1965; Chamberlin 1933, 1962) with the resource-based view of the firm (Barney, 1991). R-A theory is defined as, “an evolutionary, disequilibrium-provoking process theory of competition in which innovation and organizational learning are endogenous, firms and consumers have imperfect information, and in which entrepreneurship, institutions, and public policy affect economic performance” (Hunt & Arnett, 2004). So, competition under R-A theory states that firms are in a constant struggle for comparative advantages in resources which will result in positions of
competitive advantage for some market segments and result in superior financial performance. The main tenets of R-A theory stress the importance of (1) market segments, (2) heterogeneous firm resources, (3) comparative advantage/disadvantage in resources, and (4) marketplace positions of comparative advantage/disadvantage.

Market segments are defined as, “intra-industry groups of consumers whose tastes and preferences with regard to an industry’s output are relatively homogenous” (Hunt & Madhavaram, 2006). R-A theory posits that firms that successfully develop offerings that provide more value to customers in specific market segments will occupy positions of competitive advantage. Resources are described as tangible (physical) or intangible (non-physical) entities available to firms that enable them to produce market offerings that have value for some of the marketing segments. Resources can be categorized as financial, physical, legal, human, organizational, informational, and relational. Intangible resources, according to R-A theory, can include organizational learning, relationships, entrepreneurial skills and capabilities, culture, and brands. The inference that intangible resources are heterogeneous and imperfectly mobile is the potential for value creation and a competitive advantage.

Each firm will have some unique resource that only they possess (e.g., efficient processes, extremely knowledgeable employees, patents) that could result in a comparative advantage of resources, which in turn could result in a position of comparative advantage in the marketplace. Some of these resources are hard for competitors to imitate or acquire (relatively immobile) and so could be the source of a long-term competitive advantage. R-A theory recognizes that many of the firm’s resources within the same industry are significantly heterogeneous and relatively immobile. Accordingly, some firms will have a comparative advantage or disadvantage resulting from how effectively or efficiently they produce offerings.
that have value for market segments. Firms that have a comparative advantage in resources will in turn occupy a positional competitive advantage for some market segments. Firms with a positional comparative advantage demonstrate superior financial performance. Conversely, firms with a comparative disadvantage of resources will occupy positions of competitive disadvantage, resulting in inferior financial performance. Firms will compete for a comparative advantage in resources that will lead to a position of competitive advantage in some segments resulting in superior financial performance.

One of the foundational premises of R-A theory states that competitive dynamics are disequilibrium-provoking and innovation is endogenous. Following from its Schumpeterian roots, R-A theory exerts great focus on innovation. Innovation can be proactive or reactive. Proactive innovation occurs when firms, though motivated by the expectation of superior financial performance, are not responding to specific competitive pressures. They are acting in a classical entrepreneurial fashion. Reactive innovation is a direct prompting of the firm’s learning process because of firms’ competing in market segments. Reactive and proactive innovation both promote the dynamism of R-A competition.

Firms can learn in many ways including market research, competitive intelligence, reverse engineering competitor’s products, benchmarking, and test marketing. R-A theory states that firms can learn from competition itself. Firms learn via competition through feedback from relative financial performance signaling relative market position, which then signals relative resources. Firms that find themselves in positions of competitive disadvantage can attempt to neutralize or leapfrog the advantaged firm either through acquisition or innovation. That is the competitively disadvantaged firm will attempt to acquire the same resources as the advantaged firm and innovate by imitation of the resource, finding an equivalent, or finding (creating) a
superior resource. A superior resource implies the innovating firm’s new resource enables it to surpass the advantaged competitor in terms of relative cost or efficiency. In order for firms to maintain positions of competitive advantage they must continue to invest in the resources that produced the competitive advantage or competitors’ acquisition and/or innovation efforts fail.

**Product-Market Strategy and Innovation Performance**

Product-market strategy relates to how firms choose to compete within their chosen markets (Hughes & Morgan, 2007). Broadly speaking, Porter (1985) generic strategy framework distinguishes product market strategies based upon two dimensions: differentiation and market scope. Importantly, the effectiveness of a given product-market strategy depends upon whether the firm possesses the requisite resources needed to support its execution. For instance, implementation of an undifferentiated (i.e., low-cost) product-market strategy requires the firm to acquire or develop resources and capabilities that enable it to produce offerings of at least equal use-value at lower cost. Conversely, execution of a differentiation strategy requires the firm to acquire or develop resources and capabilities that enable the firm to produce offerings of
higher value at equal or lower cost. Given the competitive dynamics by which firms battle to attain (or counteract) positions of marketplace advantage (disadvantage), managers must continuously replenish resource stocks associated with existing capabilities as well as generate novel resource combinations in support of new or improved capabilities. Table 1 offers an overview of literature concerning product-market strategy.

A key aspect of product–market strategy is its focus on how to provide valued offerings to targeted customers through the deployment of firm resources. R-A theory suggests that firms should develop and exploit all available tangible and intangible resources that enable them to produce valued market offerings. The motivation behind examining the role played by the product market stems from the observation that firms invest in R&D because they wish to gain a product market advantage (e.g., greater product quality or a lower marginal cost). Moreover, comparative advantages in resources and resource deployment can serve to enhance the value provided (Hunt, 2000). Consistent with R-A theory, it appears of central importance that when a comparative advantage in resources is exhibited then, other things being equal, this should lead to improved levels of product–market strategy performance.
<table>
<thead>
<tr>
<th>Study</th>
<th>Empirical Context</th>
<th>Outcome Variable</th>
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<td>Hughes and Morgan (2007)</td>
<td>Cluster analysis of 1000 firms based on survey of CMEs</td>
<td>CFROA – Cashflow return on Assets</td>
<td>Using high-tech industrial manufacturers, we find that successful strategists are endowed with significantly greater levels of resources in contrast with unsuccessful strategists, hopeful strategists, and fortunate strategists</td>
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<tr>
<td>Hughes and Morgan (2008)</td>
<td>PCA using mail survey of 143 CMEs in high technology manufacturing</td>
<td>Financial performance and customer market performance</td>
<td>Fit between the strategic resources of marketing organizations and product-market strategy encourages superior financial and customer-market performance. This fit is most important to marketing organizations exhibiting either a Defender or Analyzer strategic orientation. No significant relationship is found for fit among Prospectors</td>
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<td>Hughes, Martin, Morgan, and Robson (2010)</td>
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<td>In the context of Mexican high-technology INVs, the authors find that innovation ambidexterity codetermines both marketing differentiation and cost leadership advantages, and together these link to export venture performance gains.</td>
</tr>
<tr>
<td>Authors</td>
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<tr>
<td>Yarbrough, Morgan, and Vorhies (2010)</td>
<td>Key-informant survey of trucking companies</td>
<td>CFROA</td>
<td>Empirical support for the existence of interrelationships among product market strategy decisions and organizational culture orientations. We also find support for relationships between product market strategy–organizational culture fit, and firms’ customer satisfaction and cash-flow return on assets (CFROA) performance.</td>
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<td>Zott and Amit (2007)</td>
<td>300 European and U.S. firms that conducted part of their business over the Internet.</td>
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<td>Current Research</td>
<td>Sample 309 firm-years of Gartner identified firms competing in the Business Applications category.</td>
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<td>Examines the impact of product-market strategy on innovation productivity as well as the moderating impact of measures derived from analyst’s recommendations.</td>
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</table>
**Differentiation and Innovation Productivity**

A differentiation-based product-market strategy requires the development of goods or unique services that offer unique benefits relative to industry competitors. As such, a successful differentiation strategy can increase firm profitability by creating greater customer brand loyalty and lowered price-sensitivity (Porter, 1988). Moreover, a differentiation strategy can result in products and services that are more difficult to imitate (Porter 2001).

<table>
<thead>
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<th>Table 2</th>
<th>Summary of Measures</th>
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<tr>
<td><strong>Variable</strong></td>
<td><strong>Operationalization</strong></td>
</tr>
<tr>
<td>Differentiation</td>
<td>Inverse of TNIC3TSIMM. Total similarity measure which is the sum of firm pairwise cosine similarity scores between the focal firm and all other possible competitors based on the words used by each firm. A high value indicates that the focal firm faces more potential competitive threats (see Hoberg and Phillips 2016)</td>
</tr>
<tr>
<td>Vertical Integration</td>
<td>Vertinteg; computed using the same triple matrix product used to compute pairwise vertical relatedness scores, but to compute vertical integration (a property of a single firm and not a firm pair), the observations in this data are extracted from the diagonal entries of the resulting triple product. The result is one measure of vertical integration for each firm in each year (Fresard, Hoberg, &amp; Phillips (2020)</td>
</tr>
<tr>
<td>Ability to Execute</td>
<td>ATE; Location of firm on Y-Axis of MQ</td>
</tr>
<tr>
<td>Product-Market Density</td>
<td>CD; measure of competitive proximity from MQ – distance to connect all firms in scatterplot.</td>
</tr>
<tr>
<td>Industry Concentration</td>
<td>TNIC3HHI: A Herfindahl index constructed using the text-based network industry classification</td>
</tr>
<tr>
<td>Multi</td>
<td>Coded 1 if firm competes in multiple markets; 0 if firm competes in single market</td>
</tr>
<tr>
<td>Cash Flow</td>
<td>Net cash flow from operating activities divided by sales</td>
</tr>
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</table>
Firm Size | Logarithm of total market value of equity plus book value of debt, averaged for beginning and ending of year t | COMPUSTAT
--- | --- | ---

On the other hand, successful implementation of a differentiation-based product-market strategy can entail heavier R&D investment (Miller 1987). Moreover, Biggadike (1979) suggests firm pursuing a differentiation strategy face greater uncertainty and risk with respect to these investments, since they entail bets on new market offerings that are made with limited knowledge of future changes in market preferences or the emergence of rival market offerings. In addition, innovation diffusion theory suggests many consumers may not immediately recognize the relative benefits of highly differentiated new offerings, irrespective of their potential advantages (Rogers 1981). As a result, it may often take longer for a differentiating firm to generate a return on R&D investments. As such, we propose:

**H1: Product differentiation strategy will be negatively associated with innovation productivity.**

**Product Line Vertical Integration and Innovation Productivity**

Another aspect of a firm’s product-market strategy relates to the completeness of its array of market offerings. In the context of a single firm’s product line, vertical relatedness is an indication of the extent to which firms have internal control over their inputs and outputs. Firms must continuously innovate and introduce new offerings to the market to achieve and/or maintain a competitive advantage. In turn, these new products have the ability to create transitory advantages for the firm by capturing returns on innovation (Schumpeter, 1942). However, in dynamic industries such as the software industry, these advantages are short lived (Bettis and Hitt, 1995; Bayus, Erickson, and Jacobson, 2003). Consequently, firms will build a portfolio of related products in order to create barriers to entry. Additionally, firms vertically integrate to
facilitate investments in specialized assets, protect product quality, and improve scheduling and coordination (Williamson, 1975; Chandler, 1993; Harrigan, 1984).

Vertical integration has the potential to enrich a firm’s new product development because it provides the opportunity to integrate tacit knowledge with complementary assets across different value chain activities (Teece, 1986). In technologically advanced industries, where suppliers often control vitally important new technology, internalizing these technological capabilities affords control and assures access to the knowledge necessary to build a portfolio of products based on cutting-edge technology (Afuah, 2001). Because leading-edge knowledge required for innovation tends to be found across firms, continual innovation in dynamic industries like software and technology demand firms to reach outside of their boundaries. Vertical integration can also produce spillover effects that enable firms to utilize resources to improve current products or introduce new related products.

This study will utilize the vertical textual network industry relatedness classification (VTINC) formulated by Fresard, Hoberg, and Phillips (2019). It is based on the text explaining the commodities in the Bureau of Economic Activity (BEA) input-output tables along with the text firms use to describe their businesses and product offerings in their annual 10-K disclosures. The resulting vertical integration score indicates the potential of the firms’ products to be vertically related to other products offered by the same firm. Thus, a high score would indicate the firm is offering a more vertically integrated product line. Thus, the following hypothesis is offered:

H2: A vertically integrated product line strategy will be positively associated with innovation productivity.

Moderating Effects of Ability to Execute
It is understood by successful CEOs that a significant investment of time, money, and effort is required to formulate a sound business strategy. But the real value of strategy lies in its execution. As a recent survey of portfolio managers put it: "The ability to execute strategy was more important than the quality of the strategy itself." (Kaplan & Norton, 2001). While this may run counter to deeply entrenched beliefs, the new emphasis on execution reveals a simple truth: It doesn't matter how good the plan is if you can't make it happen (Balarezo & Nielsen, 2017).

Strategic execution is complicated and time consuming and far more difficult than its formulation (Bell, Dean, & Gottschalk, 2010; El-Masri, Orozco, Tarhini, & Tarhini, 2015). Executing a strategy usually involves a change in organizational direction and a focus on effecting strategic change. According to Atkinson (2006) as many as 50% of formulated strategies never reach implementation. The challenges of strategy execution are rapidly increasing given the rate of change in business today. R-A theory states that the role of management is to recognize, understand, create, select, implement, and modify strategies (Hunt & Lambe, 2000). The structure and foundation of resource advantage rests in the ability of the organization to innovate and differentiate by utilizing their available resources. Execution often involves changes in structure, incentives, people, objectives, responsibilities etc. The firm that cannot manage change and reduce resistance to new decisions can create disaster for execution efforts (Hrebiniak 2006). As a differentiation strategy can sometimes constrain innovation productivity, the more effective a firm is at executing their strategy it should offset the slow realization of R&D innovations.

**H3: The relationship between product differentiation strategy and innovation productivity will be moderated by a firm’s ability to execute, such that the relationship will be strengthened at higher levels of execution.**
Firms competing in the software sector are often thought of as offering “complete solutions” or “stand-alone” products. Those that offer complete solutions are often thought of as vertically integrated because the buyer does not have to integrate one software solution into a larger compatible system. Firms that implement a vertically integrated product line strategy may do so though innovation (proactive or reactive) or acquisitions. Resource advantage theory depicts competition as a dynamic process through which organizations learn because of competition (Hunt & Morgan, 1996). Firms learn by competing as a result of feedback from relative market performance which signals relative market position which then signals relative resources. This organizational learning is encapsulated in the ability to execute concept discussed above. Firms that score “high” in ability to execute can continuously offer products and services that customers require and achieve relative competitive success as opportunities arise (proactive innovation), competitors act (reactive innovation), or as customer needs evolve and market dynamics change. Firms that offer a more complete solution (vertically integrated product line) will have stronger innovation outcomes at higher levels of execution. Stated another way, firms that are more adept at executing their strategies as described above and utilizing a vertical integration product line strategy will experience increased innovation productivity.

H4: The relationship between vertically integrated product line strategy and innovation productivity will be moderated by a firm’s ability to execute, such that the relationship will be strengthened at higher levels of execution.

Moderating Effects of Product Market Density

The concept of market density is not new to the literature. Greve, Baum, Mitsuhashi, & Rowley (2010) found strong support that a higher number of rivals in a given market will prompt firms to withdrawal from the market. Dobrev and Kim (2006) tested this density concept in the U.S. auto industry and found that firms tend to move from more dense markets to less dense
ones. In this study, using the Gartner Magic Quadrant as an analog for competitive dynamics, we hoped to demonstrate the disequilibrium-provoking nature of competition by analyzing the grouping of firms in specific segments over time. Each Magic Quadrant report contains a graphical representation of that market segment for that year (i.e., CRM Lead Management 2012 – 2017). Using a method (discussed later in the Methods section) we were able to derive a measure of product-market density for each segment/year.

Intuitively, the closer together the firms (the lower the value) the more similar their strategies for meeting consumer demand. A larger dispersion of firms within each MQ might demonstrate some firms seeking out more innovative solutions for their customers. Firms that practice a differentiation strategy that could lead to delayed innovation results would see additional delays in a closely grouped product market and thus:

**H5: The relationship between product differentiation strategy and innovation productivity will be moderated by product market density, such that the relationship will be strengthened when product market density is lower.**

When product market density is low (higher value) firms seek to distinguish themselves from their competitors by providing a more complete solution for their customers. This can occur through innovation or vertical integration of their product line. R-A theory views the firm as dynamically seeking to influence or (re)shape their environment (or the firm itself) either through renewal competencies and/or proactive innovations. A firm that is more vertically integrated with their product offerings already has a positive relation with innovation outcomes and so a product market that is less dense will contribute positively to the relationship between a vertically integrated product market strategy and innovation outcomes.

**H6: The relationship between vertically integrated product line strategy and innovation productivity will be moderated by product market density, such that relationship will be strengthened when product-market density is higher.**
Methods

Data and sample

The sample used in this study was a combination of three databases: the Hoberg-Phillips Data Library, the RQ database in WRDS, and COMPUSTAT. The data for the product-market strategy, differentiation, and vertical integration of the product line, were obtained from the Hoberg-Phillips Data Library covering the years 1989 - 2021. The initial sample of technology firms came from Gartner's Magic Quadrants (MQ). Gartner's library of MQs is so extensive a single category was selected, specifically a group of firms providing "Business Applications." The time frame for firms in this category ran from 2006 – 2018 and resulted in 557 firms. Many firms identified in the MQs were privately owned companies and were dropped from the sample. The RQ database contains the research quotient scores for publicly traded firms from 1990 – 2015. The resulting panel data ranges from 2006 to 2015.

Gartner is a provider of research and consulting services for businesses in the IT sector. Their Magic Quadrants offer visual snapshots, in-depth analysis, and actionable advice that provide insight into a market’s direction, maturity, and participants. Gartner Magic Quadrants are based on rigorous, fact-based analysis backed by a highly structured methodology. While the Magic Quadrant is not meant to be an exhaustive list of all firms in that specific market, the inclusion criteria may include characteristics such as installed base, types of products/services, number of clients, or some combination based on the evolving needs of their clients as buyers in the marketplace. Magic Quadrants use standard criteria in two categories: completeness of vision and ability to execute. Completeness of vision is future oriented and ability to execute is focused on the present. This study will focus on ability to execute since our independent variable is product-market strategies.
A Gartner analyst ranks the included firms based on a standard set of criteria. The standard criteria for ability to execute includes: core goods and services offered by the vendor; the overall viability of the firm including continued investment in and offering of the product; sales execution and pricing; market responsiveness to customers, competitors and market changes over time; execution of marketing strategy including increasing awareness of its products and services; customer experience including relationships, products, services, and programs to ensure client success with the product and finally; an operational measure that examines the quality of the organizational structure such as skills, experiences, programs, systems and other vehicles that enable an effective and efficient operation (https://www.gartner.com/en/documents/3956304). Each firm is then given a “low”, “medium”, or “high” ranking on each of these criterion based on the expert judgement of the Gartner analyst. An example of a Gartner Magic Quadrant is presented in Figure 1 below.
Gartner’s Magic Quadrant (MQ) provides a quick graphical representation of the competitive positioning of technology providers. A technique similar to that used by Keiningham, Cooil, Andreassen, & Aksoy (2007) was employed to derive quantitative measures from these graphical representations. The Magic Quadrant graphic was extracted utilizing the snipping tool in Windows 10 and saved as a .png file. These .png files were then imported into a plot digitizing software (http://plotdigitizer.sourceforge.net/). Each firm location on the graphic was sequentially clicked on producing coordinates which were then joined to form a polygon. Each firm now had a specific quantifiable location (X,Y). The plot digitizing software also allowed for calibration of the axes to be manually set and so the decision was made to set both axes ranging from negative 10 to positive 10.

**Measures**
Dependent Variable

This study's measure of innovation productivity is the research quotient (RQ). RQ is the firm-specific output elasticity of R&D or the exponent $\gamma_i$ in firm i’s production function (Knott, 2008). RQ is interpreted as the percentage increase in revenues from a 1% increase in R&D when all other inputs and their elasticities are held constant. Consequently, RQ is a firm-level equivalent of a common economist means of measuring industry-wide returns to R&D (Hall, 1993; Hall, Mairesse, & Mohnen, 2010).

RQ is estimated using a random coefficients model utilizing successive seven-year windows of firm financial data. Cooper, Knott, & Yang (2015) provides a more complete explanation of this estimation process and development of the RQ measure as well as the user manual for the WRDS RQ database, where we obtained the RQ data used herein. RQ was chosen as this study's measure of innovation output because of its three primary advantages over patent-based measures. First, RQ is universal and can be used for any firm that conducts R&D. Previous research indicates that fewer than 50% of firms seek patents for their R&D outcomes (Cooper, Knott, & Yang, 2018). Second, RQ is uniform because it compares output dollars to input dollars. This renders RQ as a unitless measure. Conversely, the value of patents is considered highly variable. According to Scherer & Harhoff (2000), 10% of patents account for 85% of the economic value of all patents. Lastly, RQ is reliable. More than 47 years of empirical data indicate that RQ's behavior matches propositions utilized in firm-level models of endogenous growth: RQ is indicative of increases in growth, R&D spending, and market value (Knott & Vieregger, 2018).

Independent variables

Differentiation
Hoberg and Phillips (2010, 2016) developed a new industry classification system that clarifies industry boundaries and competitiveness. The Text-Based Network Industry Classification (TNIC) is a time-varying measure of product similarity. This data is based on web-crawling and text parsing algorithms that process the text found in the business descriptions section of firms' 10-K annual filings with the Securities and Exchange Commission (SEC) and available on the Edgar website from 1996 to the present. These product descriptions are legally required to be accurate according to Item 101 of Regulation S-K. They must be updated and representative of the current fiscal year of the 10-K, allowing for a classification system that is constantly being updated with new information. These descriptions are used to create this new industry classification based on the strong tendency of product market vocabulary to cluster among firms operating in the same markets. Because these clusters are derived from 10-K business descriptions, they are based on the actual products the firms supply to the market rather than production processes (e.g., SIC and NIACS). The TNIC database is based on all domestic, publicly traded firms active on NYSE, AMEX, or NASDAQ, for which COMPUSTAT and CRSP data are available.

Hoberg and Phillips (2015) calculate firm-by-firm pairwise similarity scores by parsing the product descriptions from the firm 10Ks and forming word vectors for each firm to compute continuous measures of product similarity for every pair of firms in each year (a pairwise similarity matrix). For any two firms i and j, this algorithm generates a product similarity, which is a real number in the interval [0, 1] describing the similarity between the words used by firms i and j. Based on this, TNIC3TSIMM is a total similarity score representing a firm's total product similarity within the industry. It is a valid measure of market structure and market power. A higher score of TNIC3TSIMM indicates that the text of the firms' business
descriptions has a more common vocabulary than a firm with a lower score. This study utilizes the inverse of the TNIC3TSIMM measure as a proxy for differentiation.

*Vertical Integration*

Fresard, Hoberg, & Phillips (2020) developed the measure for vertical integration (vertinteg) used in this study. Beginning in 2012, Freesard, Hoberg, & Phillips started a project with the goal of better understanding the role of vertical relatedness across product markets and examined the relationships between vertical relatedness and innovation. The result was one measure of vertical integration for each firm year. The vertical integration score indicates the potential of a given firm's products to be vertically related to other products sold by the same firm. The higher the score, the more vertically integrated the firm is believed to be.

*Moderators*

The ability to execute measure is derived from the Gartner Magic Quadrant and is measured on the Y-axis. The criteria that Gartner considers when determining a firm’s ability to execute include the product or service offered, overall viability, sales execution and pricing, marketing responsiveness, marketing execution, customer experience, and operations. The firm’s placement on the Y-axis, when introduced into the plot digitizer, results in a specific coordinate location (X, Y). The Y values were then grouped by firm and a simple average per year was taken. The measure for competitive density was also derived from the digitized Gartner MQ, but in this case the software generated a value termed “curve length” which was used as a proxy for competitive density. A higher value indicated a more dispersed field of competitors for the given quadrant and year. A lower value would be indicative of a more tightly aligned competitive landscape.

*Control Variables*
Some firm and industry specific variables are important to control for given their possible impact on innovation output. A firm’s product market competitive environment is controlled for using the HHI (TNIC3HHI) measure developed by Hoberg and Phillips (2016). These HHI data are computed using the TNIC designations discussed above that include the firm itself in part of the HHI calculation. All HHIs are based on firm sales data from COMPUSTAT and are computed using the Herfindahl-Hirschmann sum of squared market shares formulation. Additional controls include whether the firm competes in multiple markets (0, 1) based on inclusion in multiple Magic Quadrants, firm size (market value) and the cash flows to sales ratio. This ratio calculated as net cash flow from operating activities divided by sales, reveals the ability of a firm to generate cash flow in proportion to its sales volume, and is controlled for here because it is a good indicator of overall performance between competitors in the same industry.

Two dummy variables for year (fyyear) and industry (SIC2) were also included as controls.

The resulting final model, including all interaction effects is below.

\[
\text{Innovation Output} = \beta_0 + \beta_1 \text{Differentiation} + \beta_2 \text{Vertinteg} \\
+ \beta_3 \text{ATE} + \beta_4 \text{PMD} \\
+ \beta_5 \text{Differentiation*ATE} \\
+ \beta_6 \text{Vertinteg*ATE} \\
+ \beta_7 \text{Differentiation*CD} \\
+ \beta_8 \text{Vertinteg*CD} \\
+ \beta_9 \text{TNIC3HHI} + \beta_{10} \text{Multi} + \beta_{11} \text{Cash Flow/Sales} + \beta_{12} \text{Firm Size} \\
+ \beta_{13} \text{Year Dummy} + \beta_{14} \text{Industry Dummy (SIC-2 digit)} + \epsilon_i
\]

Descriptive statistics and correlations of study variables are presented in Table 2 and Table 3 below. An examination of the correlation table (Table 3) indicates the correlation between variables is less than 0.5 and fulfills the Abdullah (2006) required values of less than 0.85.

**Analysis and Results**

Since our data is nested by the firm, we ran our hypothesized model using the xtreg command in Stata 16.0, with “gvkey” as our panel variable. Random-effects estimation fits
cross-sectional time-series regression models by using the GLS estimator and allows for time invariant variables (Damanpour, Walker, & Avellaneda, 2009).

Table 4 reports the random-effects estimates for the influences of product-market strategies on innovation output for four models. Model 1 includes only the control variables, Model 2 adds the differentiation variable, Model 3 removes the differentiation variable and adds the vertical integration variable, and Model 4 adds focal variables, moderators, and interactions. Model 4, the fully specified model, returned a within panel R-square of 0.78, which is somewhat greater than the 0.72 and 0.73 values reported for Models 1, 2, and 3 (Table 4). Model 3 also reported an overall R-square of 0.44, which is slightly greater than the 0.41, 0.36, and 0.40 values returned from Models 1, 2, and 4 respectively.
Table 3
Descriptive Statistics and Correlation Coefficients

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Innovation Productivity</td>
<td>.128</td>
<td>.076</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Differentiation</td>
<td>1.72</td>
<td>4.75</td>
<td>-0.01</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Vertical Integration</td>
<td>4.93</td>
<td>.012</td>
<td>0.05</td>
<td>0.10</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Ability to Execute</td>
<td>-5.04</td>
<td>3.492</td>
<td>-0.02</td>
<td>-0.11</td>
<td>0.19</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Product Market Density</td>
<td>-1.40</td>
<td>8.219</td>
<td>-0.11</td>
<td>0.03</td>
<td>-0.15</td>
<td>0.14</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Industry Concentration</td>
<td>.321</td>
<td>.273</td>
<td>-0.11</td>
<td>0.42</td>
<td>-0.20</td>
<td>0.00</td>
<td>0.03</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Multiple Markets</td>
<td>.193</td>
<td>.395</td>
<td>0.02</td>
<td>0.10</td>
<td>-0.11</td>
<td>0.07</td>
<td>0.10</td>
<td>-0.06</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Cash Flow (Sales)</td>
<td>.136</td>
<td>.091</td>
<td>0.03</td>
<td>-0.44</td>
<td>-0.27</td>
<td>0.06</td>
<td>0.08</td>
<td>-0.34</td>
<td>0.08</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>9. Firm Size (Market Value)</td>
<td>7.66</td>
<td>1.981</td>
<td>-0.07</td>
<td>0.13</td>
<td>-0.02</td>
<td>.024</td>
<td>0.15</td>
<td>-0.04</td>
<td>0.35</td>
<td>0.46</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Total N = 334
All models demonstrated significance according to the Wald $\chi^2$ parametric statistical measure. Model 2 tests the direct effects of product-market strategy on innovation output (H1 and H2). The direct effect of differentiation on innovation output (H1) is small but significant ($\beta = -.003, z = -2.68, p < .01$) indicating that a differentiation product-market strategy has dampening effect on innovation output, thus supporting H1.

Model 2 tests the direct effect of a vertically integrated product line strategy on innovation output (H2). The results of Model 2 demonstrate a significant positive relationship ($\beta = 1.55, z = 3.56, p < .001$) between a vertically integrated product line and innovation output. This supports our hypothesis that firms whose product lines are more vertically integrated will exhibit greater innovation productivity. Thus, H2 is supported.

H3–H6 tests various moderating effects of a firm’s ability to execute and competitive density on product market strategy. Results for H3 - H6 are from Model 3. H3 and H5 examined the moderating effects of a firm’s ability to execute on the relationship between product market strategy and innovation output. H3 proposes that the benefits of a differentiation strategy will be less negative for firms that execute well, since firms that utilize their resources most effectively to respond to customer needs and market dynamics will be more focused on innovation. In support of this hypothesis, Model 3 shows a significant positive parameter test result ($\beta = .001, z = 4.46, p < .001$) for the Differentiation*ATE interaction. Similar results were shown for H5 which proposed that the benefits of a vertically integrated product line strategy will also be increased for firms that execute well, since firms who demonstrate consistent execution will be more likely to focus on new and innovative offerings to their customers. In support of this hypothesis, the model shows a significant positive parameter test result ($\beta = .237, z = 2.21, p < .05$).
<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1 Controls Only</th>
<th>Model 2 Main Effect Product-Market Strategies</th>
<th>Model 3 Moderators and Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
<td>Coefficient (SE)</td>
</tr>
<tr>
<td>TNIC3HHI</td>
<td>-0.012** (.005)</td>
<td>0.003 (0.06)</td>
<td>0.005 (0.005)</td>
</tr>
<tr>
<td>Multi</td>
<td>0.001 (.001)</td>
<td>0.001 (.001)</td>
<td>0.002 (.001)</td>
</tr>
<tr>
<td>Cash Flows</td>
<td>0.009 (.022)</td>
<td>0.007 (.022)</td>
<td>0.034 (.022)</td>
</tr>
<tr>
<td>Firm Size</td>
<td>0.000 (.002)</td>
<td>0.001 (.002)</td>
<td>0.000 (.001)</td>
</tr>
<tr>
<td>Differentiation (H1)</td>
<td></td>
<td>-.002* (.000)</td>
<td>-0.003** (.001)</td>
</tr>
<tr>
<td>Vertical Integration (H2)</td>
<td></td>
<td>1.36* (.441)</td>
<td>0.908† (.508)</td>
</tr>
<tr>
<td>Ability to Execute (ATE)</td>
<td></td>
<td></td>
<td>0.003** (.001)</td>
</tr>
<tr>
<td>Competitive Density (CD)</td>
<td></td>
<td></td>
<td>0.000 (.000)</td>
</tr>
<tr>
<td>Differentiation*ATE (H3)</td>
<td></td>
<td></td>
<td>0.000** (.000)</td>
</tr>
<tr>
<td>Differentiation*CD (H4)</td>
<td></td>
<td></td>
<td>-0.001 (.000)</td>
</tr>
<tr>
<td>Vertical Integration*ATE (H5)</td>
<td></td>
<td></td>
<td>0.248* (.107)</td>
</tr>
<tr>
<td>Vertical Integration*CD (H6)</td>
<td></td>
<td></td>
<td>0.031* (.017)</td>
</tr>
<tr>
<td>N</td>
<td>334</td>
<td>334</td>
<td>309</td>
</tr>
<tr>
<td>Wald Chi-Square</td>
<td>796.17***</td>
<td>815.82***</td>
<td>940.68***</td>
</tr>
<tr>
<td>R-Square - within</td>
<td>0.72</td>
<td>0.73</td>
<td>0.78</td>
</tr>
<tr>
<td>- between</td>
<td>0.52</td>
<td>0.57</td>
<td>0.58</td>
</tr>
<tr>
<td>- overall</td>
<td>0.41</td>
<td>0.40</td>
<td>0.40</td>
</tr>
</tbody>
</table>

Note: *p < .10, **p < .05, ***p < .01
H4 and H5 examined the moderation effect of competitive density on the product market strategy and innovation output relationship. H4 proposed that the negative relationship between differentiation and innovation productivity would be exacerbated when there is more competitive density (fragmented market). The results for H4 are in the right direction but insignificant ($\beta = -0.001$, $z = -0.33$, $p = .74$). No support is offered for H4. Finally, H7 proposed that the positive relationship between a vertically integrated product line and innovation output would be strengthened in low competitive density markets. While the test parameter result was not significant, the indicator was positive and did approach significance ($\beta = .030$, $z = 1.71$, $p = .09$). Thus, H6 is not supported.

**Discussion**

The choice of which product-market strategy to pursue is critical not only to the overall performance of the firm but also how it will impact the firm’s innovation productivity. A key aspect of product-market strategy is its focus on how to provide valued offerings to their targeted consumers through the most efficient and effective deployment of firm resources. One of the ways firms provide valued offerings is through allocation of resources to R&D efforts that, in turn, lead to innovation productivity. Given the increasing rate of what is demanded in the marketplace, firms need to have a solid understanding of what influences their innovation outcomes. The determinants of innovation have been a topic of study for many years and are still not completely understood. The relationship between product-market strategy and innovation productivity is a perspective that has received little attention in the literature to date. Our results seem to indicate that a vertically integrated product line approach bolsters innovation productivity though we did not see as strong an influence as we would have liked we feel the results are still managerial relative. The choice of a differentiation approach demonstrated a
strong negative influence on innovation. The disparate results of our main effects would seem to suggest that product-market strategy does influence innovation outcomes.

The two Gartner-based moderators yielded some interesting outcomes. Regardless of which product-market strategy a firm chooses the ability of a firm to implement and maintain said strategy will strengthen the likelihood of achievement of desired outcomes such as overall firm performance and innovation productivity. The ability to execute, as measured by Gartner, demonstrated a strong positive influence on the negative direct relationship between differentiation and innovation and augmented the already positive relationship between vertical product-line integration and innovation outcomes. The results for our other measure from Gartner, product-market density, demonstrated no effect on the differentiation relationship, but did show a non-significant, but positive impact on a vertically integrated strategy.

This study contributes to the literature attempting to understand the many factors that can influence innovation outcomes. Previous research in this area examined various determinants of innovation such as firm size, learning capacity, market orientation, technological capabilities, or institutional support. This study adds an additional perspective to the list of possible determinants of innovation: product-market strategy. The product-market data used in this study is fairly new and has only been used in a few studies as controls. We believe this study is the first to use them as predictor variables. Our results offer support for the premise that the choice of product-market strategy employed by firms can and does impact the level of innovation productivity.

The results of this study also have several managerial implications regarding how companies should position themselves in the marketplace. The findings demonstrate that product-market strategy does impact a company’s innovation productivity. Managers of
differentiation based firms can manage customer expectations knowing that innovation productivity is coming a little slower. This would specifically impact the timing of marketing and communication regarding new items. Our findings also stress the importance of actually executing the agreed upon strategy. Managers are responsible for, among other things, making sure that strategies are implemented and adhered to. The importance of strategic execution is demonstrated in this study.

**Limitations**

As with any research, there are several limitations of this study that limit its contribution. First, the cross-sectional nature of the data inhibits exploration of any time related effects and thus any inferences of causality would be conjecture. A longitudinal approach to this data would be useful to determine if these effects were short term in nature or part of a more long-term process.

Second, our research design resulted in the study of firms that were publicly traded on U.S. based stock exchanges. Additionally, the RQ database is only calculated through 2015, so even though we had data for our independent variables through 2021, this limited our scope. This could be addressed in future research since the formula for calculating RQ is available, and all needed data could be collected from established data sources.

Third, the measures derived from the Gartner data need to be further explored and vetted. While this was an important first attempt to utilize Gartner Magic Quadrants as a data source, this was the tip of the iceberg. Due to the nature of the construction of Gartner’s ability to execute measure (composite measure based on an industry expert’s opinion), it is not strictly objective data and could be subject to biases. Regardless, there is growing evidence of the
importance of analysts and their role in improving corporate governance, managerial incentives, and firm decision making.

Fourth, the Gartner data for some sub-categories and years were missing. We do not draw any implications from the absence of this data other than to disclose it. An additional limitation that should be considered is the expense of access to Gartner data. As Gartner is primarily a consulting firm their services are worth something on the market. The Gartner data used in this study was only a small portion of the available data and focused only on one business sector, business applications. While our study could be thought of as a feasibility study for using Gartner’s Magic Quadrant as a data source in academic research, we feel the opportunities for future research are there for those willing to avail themselves. There are opportunities for longitudinal designs examining multi-market competition in high-tech firms. Utilizing the same digitization process described herein, a study examining the Gartner typology (Leader, Visionaries, Niche Players, and Challengers) and how they relate to competitive dynamics within sectors could be conceived. We strongly feel that the information contained in the Gartner Magic Quadrants represents a vast untapped source of data for academic research.

Hopefully this study will spark additional ideas that are more comprehensive than the explored model here. Future studies might want to distinguish the type of innovation being considered (incremental vs radical or proactive vs reactive). In this study, we did not differentiate and only looked at total innovation output. If those could be isolated in some way it would help managers to make decisions regarding marketing, personnel, and other resource allocation efforts. We also feel that other finance variables should also impact the relationships explored in this study. Innovation outcomes are inextricably linked to R&D spending and how
that is financed. This study hopefully adds to the discussion concerning our understanding of what drives innovation productivity.

**Overall Conclusion of Dissertation**

It is imperative for firms to continue to pursue innovation in order to remain competitive. Innovation is a positive force that contributes to firm growth and economic development, but firms still struggle with realizing systematically positive outcomes when it comes to innovation. One of the possible contributing factors to the range of results is how innovation is measured. The two essays in my dissertation examined innovation as both a driver of firm performance and as an outcome of product-market strategies using a relatively new measure that provides a more stable and objective means of understanding a firm’s true innovation productivity.

The results of essay 1 confirmed similar prior positive results between innovation and firm performance, but the true contribution lies in the moderating effects of the CEO-TMT pay gap. My results contribute to the tournament theory perspective that the pay gap between the CEO and his TMT augments the innovation – firm performance relationship. Additionally, when the overall environment is positive and supportive, a firm’s innovation capabilities matter less because everyone is doing better.

Essay 2 applies the Resource-Advantage theory of competition in light of product-market strategies and their impact on innovation productivity. While outcomes were as predicted, the choice of product-market strategy should not be viewed as an either/or decision. Firms will often use a combination of product-market strategies and the results achieved herein demonstrate that a balanced approach to the product market is best since they can act as opposing forces on innovation.
IV: REFERENCES
Essay 1


Essay 2


Afuah, A. (2001). Dynamic boundaries of the firm: are firms better off being vertically integrated in the face of a technological change?. Academy of Management journal, 44(6), 1211-1228.


