Strength in Diversity: How Board Heterogeneity Influences Investment, R&D, and Product Differentiation*

Yang Fan†

December 21, 2017

Abstract

An exhaustive literature has analyzed the function of corporate board directors as monitors, yet analyses of the advising role of corporate directors have been rare. This study fills this gap by constructing director-specific industry expertise measures for all directors of S&P 1,500 firms from 2003-2013. I analyze both the determinants of the demand for directors with diverse industry expertise as well as the impacts of director diversity on investment and firm performance. Exploiting exogenous variation on director deaths, I show that increased diversity of the board's industry expertise systematically impacts capital expenditures and R&D intensity. This expanded form of board heterogeneity is also shown to allow firms to better position their product by differentiating away from their primary competitors.

Keywords: Corporate Finance Policy Decisions, Capital Investments, R&D, Product Differentiation
JEL Codes: G34, G31

*I am extremely thankful to my advisor Mu-Jeung Yang for his guidance and continued support. I am also thankful to Phil Brock and Jarrad Harford, both whose comments have been invaluable to me.

†PhD Candidate, Department of Economics, University of Washington, Seattle, 98105. Email:*yfan@uw.edu*

In a press release on February 1st, 2016, 3M President, chairman, and CEO, Inge Thulin announced the election of Gregory R. Page to the board of 3M:

> "We are extremely pleased to welcome Mr. Page ... to our board," said Thulin. "We look forward to the valuable insight Mr. Page brings to 3M's Board from his extensive experience leading Cargill's global business. (He was)...an outstanding leader, with tremendous business experience in leading complex global organizations." [1]

1 Introduction

There is significant anecdotal evidence to suggest that directors with diverse industry expertise are highly sought after by corporate boards today for their advising and related industry expertise. The quote by 3M's president and CEO Inge Thulin of nominee Gregory Page, highlights an example of the demand for these types of directors whose diverse expertise extend beyond the same industry expertise as the board[2]. Yet, the corporate governance literature has largely ignored the advising impact of these broader industry experts[3]. This paper fills this gap in the literature by proposing a methodology that will allow analysis of all types of industry expertise areas of a director for the first time. I find that directors have many more areas of industry expertise than the literature has considered. I find that both shareholders and boards value this diversity of expertise on a board (Board Heterogeneity). First, I present evidence that this diversity of expertise is valued by shareholders by showing positive abnormal returns following the nomination announcement of one of these diverse directors. Next, I provide evidence that the demand for diverse industry expertise directors

[1] http://investors.3m.com/news/press-release-details/2016/3M-Elects-Two-New-Members-to-Board-of-Directors/default.aspx

[2] Figure 1. is an example of a director nomination announcement.

[3] The literature on advising has generally focused on prior director acquisition experience, Mkrtchyan and Field (2017) and McDonald, Westphal and Graebner (2008); prior financial expertise, Minton, Taillard and Williamson (2014),Agrawal and Chadha (2005), Cohen et al. (2014); and same industry expertise, Masulis et al. (2012) and Faleye, Hoitash and Hoitash (2017).

is driven by advising needs; needs such as the firm's growing business complexity, growth opportunities, and scope of business and not by monitoring concerns. Finally, and most importantly, I find that increased board heterogeneity has a causal impact on the long-term strategic implications for the firm's investment and R&D strategy and as a result benefits through product differentiation.

Using a sample of S&P 1500 firms from 2003-2013, I construct measures of the director's expertise using the director's prior employment history. This builds on the methodology of Masulis et al. (2012), Faleye, Hoitash and Hoitash (2017), Cohen et al. (2014) where industry expertise is linked to the the previous employer's sic. These authors used a firm's two-digit sic code to categorize firms into industries. Directors who were previously employed in these industries then had the unique industry expertise from working in that specific field. While prior authors considered only if there was an industry expertise overlap between the director and the firm[4], I extend this methodology in several important ways. First, I capture the full range of industry expertise of a director each year. This allows me to make comparisons based on the degree of similarity between directors and the director's industry expertise to the board level. Second, this paper uses both public and non-public[5] prior employment data. Prior studies, including the authors above, restrict their sample only to those firms with available sic codes in BoardEx. Crucially, I show that using only public data creates a downward bias on the level of industry expertise held by outside directors.

Directors with industry expertise different from the board, can provide the firm with a new perspective on ongoing business opportunities. Using a matched sample of outside director appointments, I show that shareholders value this diversity of expertise using an event study approach. I find that there is nearly a 0.3% cumulative abnormal return premium

[4]For example, Masulis et al. (2012) measures the proportion of independent directors on a board with same industry expertise while Faleye, Hoitash and Hoitash (2017) measures the relative number of industry experts to independent directors, the total number industry experts on a board, and a dummy for if an industry expert director is on the board.

[5]Non-public firms are firms that do not issue securities. Included are private firms, non-profits, and some governmental agencies. These non-public firms represent approximately two-thirds of all publicly held firm positions by directors. For the S&P 1,500 directors in the sample, roughly 45% of all positions held by the outside directors were non-public positions.

when the announcement of a more diverse director is made over a director that has more similar industry expertise with the board members. This is on top of 0.9% premium that others like Nguyen and Nielsen (2010) have found for independent directors. Next, using the same matched sample, I find that the cross-sectional variations in the outside director's similarity to the board can be partially explained by variations in the firm complexity, growth opportunities, and scope of business needs. This result complements a large set of literature that examines the interaction between the firm's advising needs and the firm's business environment[6].

Next, I find causal evidence that board heterogeneity increases net investment and R&D intensity and that this strategic change by the firm is productive as it supports the firm's ability to product differentiate. Not only is the impact on net investment and R&D intensity statistically significant, but it is economically significant as well. I estimate that a one standard deviation increase in board heterogeneity on average increases net investment and R&D intensities by 8.4% and 13.4%, respectively.

Since board composition is endogenous, Adams, Hermalin and Weisbach (2010), I exploit the exogenous variation of board heterogeneity due to director deaths. This instrumental variable approach builds on the approach of many authors in corporate finance including recent papers like Fracassi (2017), Fan and Yang (2017), Drobetz et al. (2017), and Nguyen and Nielsen (2010). Outside directors as innovation drivers have been studied in a very narrow sense. Ellis, Fee and Thomas (2017) find that business segment net investments increase following the introduction of outside directors that have industry expertise in that segment, though they restrict their study to only conglomerates. While they find that outside directors with industry expertise can exacerbate the internal politics problem in conglomerates and are lured by "familiarity bias" to misappropriate internal capital allocations, I find that this result may be different when viewed from the perspective of product differentiation. Consistent with literature from strategic management, the results that I find

[6]See Coles, Daniel and Naveen (2012) and Boone et al. (2007) as examples.

are consistent with the resource-based view of the director. My results complement those of Dalziel, Gentry and Bowerman (2011) and I too find that outside directors allow firms gain better product positioning in the market, however, this paper attributes the outside director's broad industry expertise while Dalziel, Gentry and Bowerman (2011) considers the directors' human and relational capital as the reason.

The results of this paper also complement that of Fan and Yang (2017) who find that board interlocks through director network connections have a significant long-term impact on innovation direction and product market direction. My paper complements that work by introducing a specific channel to which outside directors can impact innovation direction and product market direction, broad industry expertise.

One of the major reasons why this paper finds results different from prior work is specifically that this paper is the first to document that outside directors have significantly broader industry expertise that was not previously considered[7]. This is in sharp contrast to the literature's general portrayal of the homogeneous outside director. Papers like Masulis et al. (2012) and Faleye, Hoitash and Hoitash (2017) consider only one dimensional differences in outside directors such as same industry expertise overlap with the board. Other papers consider only independence, Faleye (2014) and Fahlenbrach, Low and Stulz (2015).

This paper also makes several other important contributions to the literature. First, this paper contributes to the more recent focus on the director's monitoring and advising trade-off. The results of this paper imply that the monitoring and advising trade-off as suggested by Kim, Mauldin and Patro (2014) this does not have to necessarily be the case. I find that the director/board traits that have been shown to weaken monitoring and governance in the literature, also tend to attract outside directors that are more similar to the board, the opposite of the multi-industry talented directors.

This paper is also related to the resource-based and strategic change literature. I find that multi-industry expert directors are an important information resource that is leveraged

[7]The average director in the sample has industry expertise in more than two industries.

by firms. Bharadwaj (2000) and Tanriverdi (2005) have argued that firms who operate in complex information gathering environments often seek IT resources to facilitate synergies across the firm's multiple information gathering resources. The results in this paper support this claim. I find evidence that cross-sectional variations in director-board similarities can be explained by variations in firm complexity. Moreover, the increase in board heterogeneity as a result of hiring more diverse directors, results in increase net investment and R&D intensity. Similarly, recent works like Oehmichen, Schrapp and Wolff (2017) show that industry expertise can allow firms to make strategic changes including changes in the firm's financial resource allocation profile.

Finally, this paper is also related to the recent works on product market competition and innovation. This literature describes the interaction between competition and innovation. Recent works like Aghion, Van Reenen and Zingales (2013) and Fan and Yang (2017) have turned to governance mechanisms to explain the relationship between competition and innovation. While Aghion, Van Reenen and Zingales (2013) considers institutional ownership and Fan and Yang (2017) considers board interlocks, this paper introduces board heterogeneity as a possible incentive to innovate at the firm level.

The remainder of the paper is as followed: Section 2 describes the data used in the paper. Section 3 describes the methodology behind creating the expertise measures and introduces the models that will be used to estimate the demand for board heterogeneity as well as how board heterogeneity impacts corporate polices in the future. Section 4 presents the results of the model. Section 5 concludes this paper by providing some robustness checks. To ensure that the results are not driven entirely by conglomerate firms, a robustness check examines a subsample of only single-segment firms. Next, a deeper analysis of board heterogeneity is done by examining a subsample of firms that only expand their expertise level over time.

2 Data and Summary

S&P 1,500 firms from 2003-2013 are obtained from the Compustat Constituents list. This set of firms offers a balance between a wide distribution of firm sizes and access to a relatively reliable corporate board data set. Choosing the sample period after 2002 excludes the transitional period of the Sarbanes–Oxley Act of 2002 [8]. Since firms had be compliant in most of the governance areas by 2002, using data post 2003 avoids possible board composition contamination issues that might arise during the 2001-2002 transitional periods as boards scrambled to be in compliance of the new guidelines.

Corporate board membership data is obtained from the BoardEx Organizational Summary. The match rate for BoardEx after 2003 is also markedly better than that from 2000-2002[9]. A match of 2,147 out of 2,307 possible S&P 1,500 firms between 2003-2013 is made. This consists of a baseline sample of 21,467 unique directors, 149,254 director-board-years, and 15,573 firm-years. Since BoardEx collects most director data from annual proxy statements, firms that de-list due to merger/acquisitions may not issue proxy statements in their last year. Ultimately, 15,573 out of 16,481 possible S&P 1,500 firms-years are matched.

Employment data is obtained from the BoardEx Individual Profile Employment database. The employment data consists of both publicly-traded and non-traded "private" firms[10]. Approximately 8,752 publicly-traded and 18,929 non-traded firms are represented in the sample. Additionally, these S&P 1,500 directors were(are) employed at 62,212 publicly-held and 50,700 non-publicly-held firm positions, respectively. This means that the average S&P 1,500 director with 12 prior firm positions, work at nearly 5 non-public firms.

Historical board committee data is collected from the BoardEx Board and Committee

[8]Section101 (d) of the Sarbanes-Oxley Act - Public Company Oversight Board and 301(2) - Audit Committee Selection and Oversight had SEC deadlines of April 26, 2003, which would be considered 2002 in our sample.

[9]The match rate for 2003 was 91%, while only 78% for 2002 and 72% for 2001.

[10]Private firms are more accurately described as non-security issuing firms. Many of the "private" firms used in the sample are in fact government entities or private universities. Table 1. is a list of the top 20 private institutions that employed directors in the sample. On this list are 4 private universities, 2 lobbyists, 6 US government entities, and 7 private firms.

Detail dataset. For each SP&P 1,500 director, the director's entire SP&P 1,500 board appointments and committee memberships is obtained. This is then matched to the director's biographical data; including age, gender, education, death, and social activities that are obtained from the BoardEx Individual Profiles dataset.

Table 2. summarizes the biographical details of incoming directors or directors that will join a board in the following period. Column 1 is the mean value for all incoming directors who join a board between 2004-2013, measured during the prior year. This includes all outside directors and inside promotions to the board. Since director characteristics are for the year prior to appointment, this table captures the potential characteristics of the director than might affect the hiring of the director. Column 2 and 3 are subsamples based on whether the director is an outside or insider, respectively. New incoming outside directors tend to be older and male. About a third of them have MBA degrees and a majority of them are financial experts[11]. The average incoming outside director also has been employed at more firms than the average inside director and based on my measurements, is an industry expert in almost three industries.

The S&P 1,500 firms are matched to CRSP returns. Industry returns are based on the Fama-French 12-Industry classification. I calculate daily returns and annual returns for each firm.

I create a matched incoming director-target board sample from 2004-2013 based on observed board membership data. Director and board characteristics are collected for the year prior to the connection. For the director, this data includes employment data, prior board data, and biographical data. From the firm, I collect prior performance measures (ROA, industry-adjusted returns, Tobin's Q), board characteristics data (board size, % independent...etc), and firm characteristics data (assets, revenue, net investment, R&D expenditures..etc). This dataset contains 9,768 directors, of which 852 are new CEOs and 8,118

[11]Based on Fracassi and Tate (2012), a director is a financial expert if she has an MBA or related finance degree, prior audit committee experience, works in the financial sector, or have a certification in an auditing capacity (CPA)

are considered independent by the board. Excluding the CEOs, the remaining directors are matched to 7,024 announcement dates from the BoardEx Board and Director Announcement data set.

To measure the effect of industry expertise on major corporate policies, I obtain net investment and R&D expenditures from Compustat. These are scaled by annual revenues to determine the net investment and R&D intensities. Table 3. summarizes these S&P 1,500 firms. Other performance measures of the board, ROA and Tobin's Q are also measured from Compustat data. ROA is the operating income before depreciation divided by book assets and Tobin's Q is the market value of assets divided by the book value of assets.

Two measures of product market competition are used. First, the product market segment similarity score measures the ex-post revenue similarities of the products sold by two firms across product market segments. Data on market segment revenues comes from the Compustat Historical Segments dataset. Since Compustat records these revenues based on sic classifications, the segments are converted into Fama-French 12-Industries. Not all firms report segment sales and converting 4-digit sic codes to the Fama-French 12-Industry classification reduces the segment sales of some firms to one. About 45% of firms in the sample only report segment one segment[12].

The second product differentiation measure is based on the Hoberg-Phillips Text-based Network Industry Classifications (TNIC) data set. The Hoberg-Phillips TNIC data, Hoberg and Phillips (2016), estimates the degree of similarity of the products produced between firms by measuring the degree of similarity of the product descriptions from the firm's annual 10-K filings[13]. Both measures of product differentiation are measured at the firm-pair level.

[12]The construction of the product market segment similarity score is documented in the Appendix.

[13]`http://hobergphillips.usc.edu/industryclass.htm`

3 Measurements

This section describes how the industry expertise vectors are constructed and how the similarity scores/board heterogeneity measures are calculated.

3.1 Board Heterogeneity

Board heterogeneity is the defined as the degree of difference in industry expertises of a board. This can be measured by the distribution of industry expertises of the directors or by changes in industry expertises at the board level over time. I present several ways to measure board heterogeneity in this paper. The measure presented in this section emphasizes the diversity of industry expertise between the director and the board. This measurement focuses on how different the average director is from the board in terms of industry expertise overlap.

A second measurement for board heterogeneity is presented in the Appendix. This second measure focuses on the annual changes in board-level industry expertise. I constrain the board to either having industry expertise or not. In that sense, board heterogeneity arises over time when a new incoming director brings in new industry expertise to the board that the board did not previously have.

3.2 Director Industry Expertise Vectors

A director has industry expertise in an industry if at the present time or any time in the past, has worked at some officer-level capacity in the industry. The industry is defined by the Fama-French 12-Industry classification (FF12).

Both public and non-traded firms are matched to their FF12 classification equivalents by sic codes where possible[14]. If sic codes are unavailable, industry descriptions in the sample are matched to the closest FF12 equivalent by hand. Non-public (private) firms are matched

[14] http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/Data_Library/det_12_ind_port.html

to the FF12 classification if at least three other directors have previously worked at the firm. Roughly 3,200 non-public firms remain unmatched using this procedure. These remaining unmatched firms are generally much smaller firms with very little industry impact.

Aggregating at the FF12 level facilitates the categorization of non-public firms that do not have available sic data. These firms without sic data are categorized by hand based on their best fit into the FF12[15]. Recall from the data section that roughly 45% of all director prior employers were of these non-public firms. Therefore, this necessary simplification allows me the ability to utilize this entire dataset.

A director's industry expertise at time t, is a 1x12 vector. Each element in the vector is either a 0 (if the director has no current or prior executive-level experience in the industry) or 1 (if the director has current or prior experience in the industry). Directors are assumed to not lose expertise over time. Once a director gains industry expertise by having experience in the relevant industry, the director is considered to be an expert in the sample.

Table 4. is an example of how a director's resume is decomposed into an industry expertise vector. Panel A is the resume of Steve Jobs. Each prior employer of Jobs is classified by sic code (column 6) and translated into the appropriate FF12 equivalent (column 7). Only the positions in which Jobs held at an executive or director level are considered. Jobs' industry expertise is primarily in the Information Technology Hardware and Media-Entertainment sectors but he gains industry expertise in the General Retailers industry when he becomes a director at The Gap Inc in 1999.

Panel B. demonstrates how to translates Jobs' resume into annual industry expertise vectors. In 2000, Jobs' industry expertise vector now shows that he is an industry expert in FF9 as a director at The Gap Inc. Going forward, Jobs will always be an industry expert in this industry. The industry expertise vector of Jobs is quite typical of outside directors in the sample. The average director has industry expertise in more than two industries in the sample (Table 2.).

[15]The uncentered correlation proximity method that I use to calculate the similarity score is not affected by the categorization size. This is discussed in the appendix.

3.3 Board Expertise

Board industry expertise can be aggregated from the industry expertise of board members. Motivation for this aggregation of expertise at the board level can bee seen from survey evidence[16]. Results from annual surveys of corporate directors suggests that boards often decide on nominees based on board expertise deficiencies[17].

Table 5. is an example of how the board industry expertise vector is aggregated from the twelve incumbent board members of Walt Disney in 2005. Each incumbent director has an annual 1x12 industry expertise vector based on current and prior work experience. For each of the FF12 Industries except non-durable goods production (industry two), the board has at least one board member that has industry expertise. Thus, in 11 of the 12 categories, the board has industry expertise. Therefore the annual board industry expertise vector is a 1x12 industry expertise vector with 1's in every column except FF12 category 2. More detail on how board expertise is constructed is in Appendix 6.2.

3.4 Board Heterogeneity Measure

Board heterogeneity is a measurement of the diversity of industry expertise of the board members on a board. This diversity can be the result of board members having different industry expertise combinations or directors who are specialists and contributes a unique industry expertise not shared by other directors.

For some director D_1 that presides on board B_k at time t, the degree of industry expertise similarity between the director and the board is given by the an uncentered correlation in equation 1. This director-board similarity score measure captures to what degree

[16]PWC's Annual Corporate Director's Survey 2017: `http://www.pwc.com/us/en/governance-insights-center/annual-corporate-directors-survey/assets/pwc-2017-annual-corporate--directors--survey.pdf`

[17]PWC's Corporate Director's Survey 2017 found that digital/IT and cybersecurity expertise were two of the most cited industry expertises that boards were actively seeking to fill.

the director's industry expertises overlap with the board's expertises.

$$S_{k,i,t} = \frac{B_{k,t}D'_{1,t}}{(B_{k,t}B'_{k,t})^{\frac{1}{2}}(D_{1,t}D'_{1,t})^{\frac{1}{2}}} \tag{1}$$

To consider board heterogeneity differences over time, first I construct an average director-board similarity score as in equation 2 by averaging across the directors on the board. This equation is interpreted as the similarity between the average director and board. For values of $\overline{S_{k,t}}$ that are large,it is implied that there is a great deal of substitutability between directors on the board based on industry expertise. In other words, if a director were to resign, there would be sufficient overlap in industry expertise provided by other directors that the board level expertise would not change much.

$$\overline{S_{k,t}} = \Sigma_i^j S_{k,i,t} \tag{2}$$

A change in the average director-board similarity score shows how board heterogeneity changes over time:

$$\Delta\overline{S_{k,t,t-1}} = \overline{S_{k,t}} - \overline{S_{k,t-1}} \tag{3}$$

Hence, there is difference between a board comprised primarily by specialists verses a board comprised by generalists. A board with primarily specialists would lose board expertise if a director were to resign. This would not necessarily be true for a board filled with generalist. Consider Walt Disney's board in 2005 (Table 5.). The average director-board similarity score in 2005 of Walt Disney was 0.63. While smaller than the median director-board similarity score for S&P 1,500 firms in 2005 (0.667), Table 5. shows that there is still quite a dispersion of industry expertise in directors. This implies that the majority of the directors on the board are generalists with a broad range of industry expertises.

To test whether or not shareholders value directors with more heterogeneous industry expertise and whether boards demand these directors, a matched sample of incoming direc-

tors and the board is created. Here, the director-board similarity score is measured at time $t-1$ for directors that join a board at time t. Given industry expertise vectors at time $t-1$, the director-board similarity score for incoming directors is given by equation 4 below.

$$S_{k,i,t-1} = \frac{B_{k,t-1}F'_{1,t-1}}{(B_{k,t-1}B'_{k,t-1})^{\frac{1}{2}}(F_{1,t-1}F'_{1,t-1})^{\frac{1}{2}}} \tag{4}$$

If boards tend to hire directors that already have overlapping industry expertise with the board, the $t-1$ director-board similarity scores between the incoming director and the board would be very large and close to one and when compared to the next period's t score, the two similarity scores would be very similar. In contrast, if the director and the board are very different at $t-1$, the similarity score would be very small and the difference in the similarity score over time will be large.

One potential issue with equation 4 is that firms with larger board sizes can possibly have more board expertise simply by having more directors. This may unintentionally cause the director-board similarity scores to be higher if the boards have more expertise. Therefore, I also construct a similarity score measure that is weighted by the board size where Z_k is the size of board k.

$$S_{k,i,t-1,weighted} = \frac{\frac{B_{k,t-1}F'_{1,t-1}}{(B_{k,t-1}B'_{k,t-1})^{\frac{1}{2}}(F_{1,t-1}F'_{1,t-1})^{\frac{1}{2}}}}{Z_k} \tag{5}$$

To see how board heterogeneity can change when a director joins or resigns from a board, consider the example of Jobs joining the board of Disney in 2006. The similarity score between Jobs' industry expertise and that of the board of Disney is 0.52. While there is overlap in industry expertise between Jobs' and the board, there is still considerable diversity in expertises. Therefore, upon joining the board, the average director-board similarity score drops slightly from 0.63 to 0.61. Likewise, when Jobs' dies in 2012, the average director-board increases from 0.65 to 0.67. This measurement of board heterogeneity emphasizes the differences in the distribution of industry expertises between the directors and the board.

4 Methodology

4.1 Demand for Board Heterogeneity

Figure 3. Panel A plots the annual average number of industry expertises of a firm between 2003-2013. There has been a gradual and consistent increase in the number of industry expertises at the board level (7.03 in 2003 to 7.56 in 2013). A Wilcoxon test shows that this change is significant.

Panel B. normalizes the total number of industry expertises per board by the board size to control for the number of directors. The results remain the same and a Wilcoxon test shows that this change is also significant. Firms are gaining industry expertises over time and these are unique Fama-French 12-Industry expertises.

Since board industry expertises are a result of director industry expertises increasing over time, a natural question to ask is whether all directors are becoming equally diverse in industry expertise or if directors are individually becoming more different and contributing different types of industry expertises to the firm. If the former were true, then the annual director's similarity in industry expertise would remain constant. However, Figure 2. implies that this is not the case. The average director similarity score has been decreasing as well, indicating that each director that joins a board over time is slightly more different than the board in terms of industry expertise. In other words, the reason why boards gaining more diverse industry expertise must be coming from the fact that directors are becoming more diverse in industry expertise as well.

Next, I consider source of this demand for board heterogeneity in two ways. First, the systemic increase in diverse directors must be valued by shareholders. While directors are still by majority nominated by the board, shareholders have gained significant influence over nominations through new measures by the SEC[18] and through the activities of activist

[18]Since Aug 25, 2010, new measures adopted by the SEC require proxy materials to include director nominations of long-term shareholders.

shareholders[19]. Therefore, I consider a event study approach to analyzing abnormal returns around the announcement of these directors. Second, since there is an observed equilibrium rise in diverse directors, I construct a model to examine some of the demand determinants of these diverse industry expertise directors.

To study the rise in board heterogeneity, I construct a matched sample of directors who join S&P 1,500 boards. First, I consider directors at time $t-1$ who will join a firm the following year at time t. I consider only directors who do not become CEOs of the target firm. Since some directors are hired as part of the CEO-succession plan, I exclude incoming directors that become CEO within 3 years of joining the board. A much smaller sample of directors are promoted to the board from within. These are current executives who join the board as insiders.

To evaluate the value of board heterogeneity by shareholders, a standard event study is conducted on the announcement returns of directors who are hired to the board. For each incoming outside director, a measurement window of [-210,40] is used to generate the predicted return by the firm. An event window of [-4,+1][20] is used to measure the abnormal returns. There are 7,024 matched new director announcement dates in BoardEx. Each incoming director's announcement date is matched for other announcements of resignations, internal promotions, earnings, mergers/acquisitions, and committee membership details. Directors were excluded if other announcements were made 30 days prior to the new director announcement date. The remaining director announcement dates were then filtered for other types of company news events[21]. Of the 7,024 directors with announcement dates, 1,301 director announcements fit the criteria as independent events.

[19]According to FactSet's SharkRepellent, there has been a four-fold increase in the number of attempted proxy campaigns between 2010-2013 (253). While many of them do not reach a proxy vote, many still are resolved through a proxy settlement.

[20]The choice of the [-4,+1] event window is based on Masulis et al. (2012) whose announcement return methodology is closest to mine. Nguyen and Nielsen (2010) uses an event window of [-1,+2] but that announcement is in regards to a director death.

[21]News searches were made for firm related news during the event window. Firms that had news pertaining to litigation or litigation updates, FDA announcements, new product lines, missed earnings, or shareholder meetings overlapping were also excluded from the sample.

Next, I consider the demand for board heterogeneity from the board. There is a growing body of literature that suggests a significant trade-off between the monitoring and advising performances of outside directors[22]. Therefore, to determine how board heterogeneity plays a role in shaping corporate policies, I first consider how the weakened monitoring of the board may impact on the type of director that is elected. The issue at hand is that the similarity score gives no indication of whether the director hired is for monitoring or advising purposes. If poor governance gives rise to outside directors with lower similarity scores, this may provide evidence of this monitoring/advising trade-off.

From the corporate finance literature, I include controls for the determinant of the demand for directors and categorize them as monitoring or advising. First, I control for whether or not a social networking connection exists between the board and the incoming director based on Fracassi and Tate (2012)'s social-networking links. This work follows from a long line of anecdotal and survey evidence that suggests that directors are chosen primarily by other director recommendations[23]. Survey evidence suggests that while most nomination committees are ultimately responsible for finding the new director, the pool of potential directors still often results from word-of-mouth recommendations between the directors on the board.

I build on Fracassi and Tate (2012)'s social connection methodology by searching for existing relationships between the incoming director and the entire board at $t-1$[24]. These social connections are based on prior education ties, prior employment overlaps, current employment overlap, and other outside activity overlaps[25]. If social connections exist between

[22]See Brown, Dai and Zur (2016) and Kim, Mauldin and Patro (2014) as examples.

[23]see PwC's Annual Corporate Directors Survey 2016 and Annual GSB Stanford: Board of Directors Evaluation and Effectiveness Survey: https://www.pwc.com/us/en/corporate-governance/annual-corporate-directors-survey/assets/pwc-2016-annual-corporate--directors--survey.pdf and https://www.gsb.stanford.edu/sites/gsb/files/publication-pdf/cgri-survey-board-directors-evaluation-eff pdf, respectively.

[24]Fracassi and Tate (2012) examines social links between the CEO and incoming director. Fracassi (2017) examines social links between firm pairs.

[25]A social connection exists if *any* of the four connections are made. I consider both a weak connection and a strong connection. A strong connection exists if 1) prior education cohorts graduate within a year of year other and 2) outside social activities memberships are of as an officer or above.

the incoming director and a member on the board, the similarity between the two may be driven entirely by prior correspondence and not due to any demand for industry expertises of the director by the board.

From Hermalin and Weisbach (2003), I control for CEO power in the firm. CEOs with more bargaining power in the firm may be able to surround themselves with directors that they can control. By exerting influence over the board, the CEO may be more likely to appoint directors who are more similar to the firm due to prior connections with the CEO as opposed to directors with desirable industry expertises. Therefore, I include proxies for CEO power by controlling for CEO tenure and dual CEO-chairman roles[26].

Three firm performance measures are used, Tobin's Q, ROA, and the firm's prior two year industry-adjusted return. Firm complexity is measured by the number of product market segments participated by a firm and by the firm's current board size. The literature has explored the economic determinants of board structure[27]. Since boards with more industry expertise may be a direct result of the firm's complexity, I also control for the total number of industry expertises on a board based on the incumbent director's expertises.

Finally, I include several director and board characteristics. These characteristics include the director's age, gender, and the percentage of independent board members on the board. I also control for the total number of industry expertise categories of the director. Directors with more overall industry expertise across all categories may mechanically have a larger similarity score with high expertise boards.

The monitoring, advising, and director characteristics can be broadly categorized into director characteristics, firm characteristics, and board characteristics. Formally, I estimate

[26]There is a large literature that looks at the effects of CEO power. SeeGraham, Kim and Leary (2017), Li, Lu and Phillips (2016), and Shivdasani and Yermack (1999) to name a few.

[27]Using a random sample of firms, Markarian and Parbonetti (2007) find that director allocations to firms based on director classifications are not random. Externally complicated firms are more likely to employ "community influentials" as opposed to "insiders." Similarly, Coles, Daniel and Naveen (2008) finds that board size is directly related to firm complexity and scope of business needs where firms that have greater advising requirements typically have larger boards.

the demand for diverse industry expertise directors by the equation 6 below:

$$SimScore_{i,k,t-1} = \beta_0 + \beta_1 Dir_{i,t-1} + \beta_2 Firm_{k,t-1} + \beta_3 Board_{k,t-1} \tag{6}$$

I consider multiple specifications for the model in equation 6. All specifications are based on outside directors who join the board as non-CEOs. Table 9, Columns 1 and 2 consider Tobin's Q as the performance measure of the firm. Column 1 measures firm complexity and scope of business by the board's total number of industry expertises. A firm that is more complex with greater advising needs is assumed to have a more diverse set of industry expertise already on the board. Column 2 measures firm complexity based on the number of industry segments and the board size.

Columns 3 and 4 measures the board demand for heterogeneous directors by considering the performance measures of ROA and the prior industry-adjusted excess return. Column 1 to 4 follows Fracassi and Tate (2012)'s specification for establishing a social connection between the incoming director and the board. A "weak" connection is a more conservative approach in establishing a link between board members. This means that a connection is more conservatively likely to exist. The differences between a "weak" connection and a "strong" connection include requiring a maximum one year degree award date separation for an education connection or officer status in other social activities for a strong connection to exist.

4.2 Net Investment and R&D Intensity

To consider the impact of board heterogeneity on strategic corporate policies, I consider net investment and R&D intensity. The literature surrounding the determinants of innovation and the impact of outside directors as advisors has been a source of great discussion. Survey evidence like the ones previously discussed, point to directors playing a central role in

deciding major firm strategies and initiatives, yet the literature remains divided in how to approach measuring the impact of the director on major strategic policies. Ellis, Fee and Thomas (2017) comes closest to my approach by constructing a narrative in which conglomerates hire outside directors with specific expertise in the their sectors. These outside directors increase net investment but at the aggregate, the investments are wasteful due to inefficiencies of internal capital allocation. This story is at odds with the resource-dependency literature of Tanriverdi (2005) and Fan and Yang (2017) who finds evidence of major innovation directional changes following board interlocks. Moreover researchers like Aghion, Van Reenen and Zingales (2013) argue that governance features like block ownership, can play an important in focusing long-term R&D projects. This suggests that the net investment and R&D expenditures that occur due to outside director advising must be deliberate. If outside directors are demanded and valued for their advising capabilities and their benefits are in bringing in expertise that the board does not have, then these outside directors with the most unique perspective, should be the ones that generate the highest intensities of net investment and R&D.

I measure the effect of an increase in board heterogeneity on net investment intensity and R&D intensity. However, since board composition is endogenous, firms with long-term projects in place may seek out industry experts to see them through. Under this explanation, outside directors play a much smaller role, one that only provides oversight to projects. Thus, I use director deaths as an instrumental variable in determining the causal impact of board heterogeneity changes on net investment and R&D intensity changes.

Equation 5. measures the demand for board heterogeneity by decomposing the demand into monitoring and advising parts. Even after controlling for monitoring, I find that the demand for diverse industry expert directors can be explained by the demand for them as advisors. To access the effect of board heterogeneity on net investment and R&D intensity,

I estimate the following IV regression for firm k for net investments:

$$\Delta SimScore_{k,t,t+1} = \beta_0 + \beta_1 Death_{k,t,t+1} + \beta_2 Controls_{k,t,t+1} + \epsilon_{t,t+1} \tag{7}$$

$$\Delta NetInvest_{k,t+1,t+2} = \gamma_0 + \gamma_1 \Delta \hat{SimScore}_{k,t,t+1} + \gamma_2 Controls_{k,t,t+1} + \omega_{t,t+1} \tag{8}$$

and for Δ R&D:

$$\Delta SimScore_{k,t,t+1} = \beta_0 + \beta_1 Death_{k,t,t+1} + \beta_2 Controls_{k,t,t+1} + \epsilon_{t,t+1} \tag{9}$$

$$\Delta R\&D_{k,t+1,t+2} = \gamma_0 + \gamma_1 \Delta \hat{SimScore}_{k,t,t+1} + \gamma_2 Controls_{k,t,t+1} + \omega_{t,t+1} \tag{10}$$

Director deaths are aggregated at the firm level annually. There were four cases where a firm experienced more than one director death annually. Therefore, the director death variable, *Death*, takes on the value of 0, 1, or 2. I also include other controls. At the firm level, I control for the change in assets between time t and $t+1$. Prior performance is based on the prior two-year industry adjusted excess returns for the firm. At the board level, I control for the total number of directors on the board, the number of independent directors, and the average age of board members. These board level controls are to control for the other board dynamics that may change following the death of a board member. Note in this framework, the change in the similarity score already controls for the change in the areas of industry expertise of the remaining board members. To ensure that industry and year effects are not driving the results, I also include Fama-French 12-Industry and year fixed effects.

Director deaths are a suitable instrumental variable because when a director death occurs, a vacancy on the board is created. Public corporate boards, especially the larger firms in our sample, are governed by corporate bylaws enacted by and ratified by the board[28]. These bylaws stipulate the minimum and maximum number of directors for the board, the

[28]See Microsoft Bylaws as an example:
https://www.sec.gov/Archives/edgar/data/789019/000119312508201369/dex32.htm

types of board committees and committee membership procedures, and most importantly, the nomination process for directors. Nearly all of the S&P 1,500 firms in the sample nominate new directors at annual shareholder meetings, with proxy materials distributed in advance. Under normal circumstances, succession planning begins when a director informs the board that he/she is planning on resigning. Most boards do not have director succession plans in place. The director normally stays on until the next annual shareholder meeting when another director can be nominated. In the event of immediate resignations, vacant seats are left open until the next annual meeting.

Director deaths are unexpected and the vacancy implies that the board loses any industry expertise that the director had. There are potentially two effects on the board. The level of board industry expertise can be affected if the director has exclusive industry expertise that no other board member has. The second effect on the board can come from the overall mix of the director's industry expertise. A loss of a director with very diverse industry expertise can affect the firm in a very different way than a specialist director can.

Table 10. summarizes the director deaths in the sample. In total, 312 director deaths are observed in the sample. Compared to the 9,881 directors that exit in the sample[29], directors who die tend to be slightly older, more tenured in the firm, more likely to be an independent director, and in a firm with slightly less board heterogeneity when compared to the sample average. Overall, the director death seem to be a reasonable representation of the the group of directors that exit a board. The smaller board heterogeneity score is precisely the reason why director deaths cause board heterogeneity to fall (director-board similarity scores to rise).

4.3 Product Differentiation

Next, I turn to whether the change in net investment and R&D intensities following increases in board heterogeneity is beneficial to the firm. Ellis, Fee and Thomas (2017) argues that

[29] A director exit occurs when a director leaves the board of the firm at least 2 year before the last board date in the sample.

within a conglomerate framework, familiarity bias leads to internal capital mis-allocation. They argue that this leads to unproductive investments into pet projects which ultimately is detrimental to the firm's performance. However, performance measures are noisy and subject to demand shocks. Moreover, R&D is inherently risky and may yield no result, thus I approach this question from the lens of product differentiation instead.

I use two measures of product differentiation. The first measure of product differentiation uses the similarity of ex-post revenue shares[30]. This measure captures the effectiveness of the increase in net investment and R&D intensities in generating revenue streams in other business segments. If outside directors with more diverse industry expertise provide advice and new perspectives that open up new product lines or expand outside the firm's core business, evidence of this may be found in where the firm is generating revenue from. If outside directors help deploy internal resources efficiently, then their industry expertises might allow them the ability to see different opportunities which the firm should be able to, on average, better position themselves in the product market space. I estimate this using equations 8 and 9 below.

$$\Delta SimScore_{k,t,t+1} = \beta_0 + \beta_1 Death_{k,t,t+1} + \beta_2 Controls_{k,t,t+1} + \epsilon_{t,t+1} \tag{11}$$

$$\Delta PMSS_{k,t+1,t+2} = \gamma_0 + \gamma_1 \Delta \hat{SimScore}_{k,t,t+1} + \gamma_2 Controls_{k,t,t+1} + \omega_{t,t+1} \tag{12}$$

The same empirical strategy is employed. Using director deaths as an instrumental variable, I attempt to establish a causal link between increases in board heterogeneity and product differentiation in the firm's product market space.

While the first measure of product differentiation in a sense, measures the successes of a firm's ability to transition the business, the second measure is an ex-ante product differentiation measure. The Hoberg-Phillips (HP) Text-based Network Industry Classifications data set is based on regulatory statements. Each year, firms self-report 10-K product descriptions

[30]see Appendix for a more detailed discussion on how this measure is constructed

that have to be lawfully accurate. Unlike the similarity scores calculated by ex-post revenue streams, these product descriptions are ex-ante and forward-looking. If outside directors help efficiently redeploy internal resources, the new product direction will be evident by the key word descriptors that they provide on their regulatory statements. Thus, to measure this, I estimate equations 10 and 11.

$$\Delta SimScore_{k,t,t+1} = \beta_0 + \beta_1 Death_{k,t,t+1} + \beta_2 Controls_{k,t,t+1} + \epsilon_{t,t+1} \tag{13}$$

$$\Delta HP_{k,t+1,t+2} = \gamma_0 + \gamma_1 \Delta \hat{SimScore}_{k,t,t+1} + \gamma_2 Controls_{k,t,t+1} + \omega_{t,t+1} \tag{14}$$

5 Results

Three main empirical facts motivate this paper. First, outside directors have diverse industry expertises. According to Table 2., the average outside director has industry expertise in almost three Fama-French 12-Industry classification industries. Figure 2. Panel B plots the timer-series change in average industry expertises of outside directors. Part of this discrepancy could be due in part to most literatures ignoring the employment of directors at non-public firms. Outside directors on average have been employed at 8.5 prior firms. Based on the BoardEx employment sample, more than 50% of the employer firms are private firms. For studies that have focused on only public firm data, this implies that the literature has vastly underestimated and undervalued the different industry expertises of outside directors.

Second, there has been a sustained decline in the average similarity between directors on a board over time. Figure 2. panel A. and Table 7. both show a gradual but consistent decline in this similarity score over time. This decline is statistically significant[31]. There are two possible explanations to this and both offer support that the current homogeneous outside director interpretation is incorrect. One possible explanation is that directors are

[31] A Wilcoxon signed rank test rejects the null that the average similarity score of directors on a board has been constant over the sample period

increasingly becoming specialists and boards are hiring specialists that do not overlap in terms of industry expertise each other. While can be a possibility, this is unlikely due to the fact that the average outside director has industry expertise in almost three industries. The other explanation is that while there is industry overlap, directors are gaining considerable non-overlapping industry expertise as well. This seems to be more likely the case. Figure 2. panel B. shows that the annual average director industry expertise is rising both for all incoming directors and outside directors, though at the level, the outside directors have more industry expertises by a significant margin. In other words, outside directors have broader ranges of industry expertise and it is the mix of industry expertises that are of value to shareholders and the board as it allows the director to provide a unique perspective on the business environment from the lens of multiple industries. Both of these explanations are in contrast to the current literature's treatment of outside directors as ones with same industry expertise (Masulis et al. (2012) and Faleye, Hoitash and Hoitash (2017)) or explicit experience as financial experts or acquisitions (Minton, Taillard and Williamson (2014) and Mkrtchyan and Field (2017)). This is something that I will examine closely in the following sections.

Finally, board industry expertise has increased substantially over the sample. Figure 3. and Table 6. provide this empirical fact. Table 6. shows that the mean annual average number of total industry expertise on a board has increased from 7.03 in 2003 to 7.56 in 2013. This is also statistically significant[32]. There are two noteworthy points here. First, the average S&P 1,500 firm has a large number of different industry expertise areas. Few papers have even looked at how board expertises can affect the firm. These papers have considered only related industry expertise, Dass et al. (2014), or political expertise, Agrawal and Knoeber (2001). To my knowledge, no author has examined just how many expertises a board is associated with. Second, the number of industries that a board gains expertise in, is rising over time. This means that boards are either leveraging outside directors to increase

[32]A Wilcoxon signed rank test here also rejects the null that the average number of total industry expertises on the board has remained constant.

expertise not found on the board or incumbent directors are seeking board seats in other industries and bringing expertise back to the firm. according to Figure 2. panel B, both are true.

In all, these three facts point to a need for a more thorough analysis of the impact of diverse industry expertise on boards. To see how this board heterogeneity affects the firm, I first consider whether or not shareholders value this additional expertise by examining announcement returns of nominations of directors with different industry expertise. Next, I consider some of the demand determinants of board heterogeneity from the firm's perspective.

Finally, I consider the impact of board heterogeneity on the long-term strategic direction of firms. This emphasizes the advising effectiveness of these directors in how they are able to shape the long-term direction of the firm.

5.1 Shareholder Gains from Announcement Returns

I find that shareholders value outside directors with more different industry expertise backgrounds as the board. Table 8. summarizes the key results. There is a statistically significant 0.28% announcement return premium for outside directors using a [-4,+1] event window. The sign of this abnormal return complements studies like Nguyen and Nielsen (2010) who find a -0.85% abnormal return from an outside director's death. The differences in the size of the abnormal return can be possibly attributed to the different sample periods used. Nguyen and Nielsen (2010) uses 1994-2007, a period when outside directors increased substantially due to compliance with Sarbones-Oxley [33].

While the 0.28% abnormal return is statistically significant, when broken down by similarity of outside director to the board at $t-1$, outside director with less similar industry expertises are much more valued by shareholders. I find evidence of a +0.45% announcement return premium of less similar outside directors. The same is not observed for outside

[33]In my sample 2002-2013, outside directors account for over 80% of all board members and that number has held fairly steady for a number of years. However, the outside director percentage rose dramatically from under 50% in 1996 to over 70% in 2005 according to Duchin, Matsusaka and Ozbas (2010)

directors who more similar to the board they are about to join. For inside directors or directors who are to be promoted from within the firm, the results are even of the opposite sign, though insignificant. For each of these categories, I compare the new director-board similarity score to the median similarity score value for the year.

Taken together, the results suggest that shareholders do value outside director appointments to the board, but not because they are simply outsiders, rather the shareholder's positive view is driven by the outside directors potential industry expertise contribution to the board.

5.2 Demand for Board Heterogeneity

Next, the results of the demand determinants of board heterogeneity are presented in Table 9. Here, I examine the ex-ante characteristics of new director-board connections the following year. I find evidence that more complicated firms are associated with the hiring of directors that are bring in unique outside industry expertise. In columns 2-4, firm complexity is measured by the number of Fama-French segments and larger board sizes. I find firms that participate in more product market segments are related to the hiring of more different outside directors. These outside directors have more different industry expertise than the board's level of expertise. These results are consistent with the findings of Markarian and Parbonetti (2007) and Ellis, Fee and Thomas (2017) that find that firm complexity is tied with outside director expertise. The result is also evident when I consider board size as well. Larger boards tend to hire more heterogeneous outsiders. Again, columns 2-4 show a strong negative relationship between board size and similarity of the director with the board. Theory has suggested that smaller boards may reduce agency costs and asymmetry of information among board members but our results are consistent with the broader empirical findings of Coles, Daniel and Naveen (2008), Boone et al. (2007), and Linck, Netter and Yang (2008) who find that larger board are favored by firms that have organizational complexity and a greater dependence on external resources.

Not all firms report segment sales in to different FF12 industries and not all complex firms sell into different industry segments to begin with. In the sample, roughly 30% of all firm years of the S&P 1,500 firms did not report segmented FF12 sales. To ensure that the results are not driven by conglomerate firms, I use the board's *Total Industry Expertise* as a proxy for firm complexity. In column 1, the results show that there is a statistically significantly negative relationship between the total number of board expertises and the hiring of similar directors. Taken with the evidence from the number of segments, the results suggest that firm complexity and directors with different industry expertises are strongly related. Complex firms have a tendency to hire more different directors and this results is generalized to all firm types, not just conglomerates. From an advising perspective, the results are consistent with Faleye, Hoitash and Hoitash (2017) in that outside directors with industry expertise can help a firm with complex business needs such as advising firms on industry risks and regulations which can therefore contribute to firm value in the future.

Next, columns 2-4 compares different firm performance measures of the firm at $t-1$. Prior ROA and industry-adjusted returns do not seem to motivate the hiring of directors with different expertises where as a lower Tobin's Q does (column 2). One possible explanation for this is that ROA is an accounting-based performance measure. When ROA is high, the results can be due to successes of previous managerial actions, Hutchinson and Gul (2004). The same logic can be applied to the industry-adjusted returns that are insignificant. These measures are backwards looking and only reflect short-term successes based on decisions made in the past. Tobin's Q though, can reflect the firm's growth opportunities, Bozec, Dia and Bozec (2010). The positive relationship between Tobin's Q and director similarity score suggests that when firms are undervalued, the board seeks advice from outside help. In our sample of S%P 1,500 firms, the lowest Tobin's Q value is still greater than 1. The results could suggest that the firms with Q values at the lower end, may benefit the most from investments because they are undervalued. To make the most of their investments, they turn to outside advisors. Taken into context with the results from ROA and industry-

adjusted returns, this set of results suggests that the advising sought after by boards from directors of different industry expertises is advice that can aid the firm in long-term strategic planning. This is explored in the next section.

Finally, the results of the demand for board heterogeneity also suggests that firms associated with weaker corporate governance (poor monitoring), hire outside directors that are more similar to the board. A director that has a pre-existing relationship based on the Fracassi and Tate (2012)'s social connections[34], results in a director hiring that decreases board heterogeneity. In other words, the new incoming director is more likely to overlap in industry expertises with the board. This result is unsurprising in the sense that survey evidence has always pointed to the fact that the pool of potential outside directors has predominately come from word of mouth[35]. Since social connections also include prior and current employment relationships, it is unsurprising that existing social connections leads to increased board similarity.

While CEO power (CEO tenure and CEO-Chair dual title), has been well established in the literature as source of weakened corporate governance[36], our results do not show that. One possible explanation is that while CEO power may result in hiring directors as poor monitors, this does not seem to impact the industry expertise similarity of the director.

Boards with a greater percentage of independent directors are also more likely to hire outside directors with different industry expertise. This result is consistent with the monitoring mechanism literature that boards with more outsiders increases firm transparency and reduces agency costs[37]. This result is also consistent with the advising literature in that boards with a larger proportion of independent directors also tend to have more advisory

[34]A social connection exists if there is a education connection, prior employment connection, current employment connection, or connection from other social activities.

[35]See the annual corporate directors survey by pWc and annual board of directors evaluation and effectiveness survey by TMG

[36]See seminal works by Westphal and Zajac (1996), Daily and Dalton (1997), Hermalin and Weisbach (1988) and more recent works by Albuquerque and Miao (2013) and Graham, Kim and Leary (2017).

[37]See Byrd and Hickman (1992), Brickley, Coles and Terry (1994), Westphal and Zajac (1996), and Borokhovich, Parrino and Trapani (1996) as well as more recent work by Henry (2004) who suggests that agency costs are lower the higher the number of independent directors on the board.

needs. Much like firms with more product market segment participation, boards with higher director independence percentages may be a proxy for firm complexity

The results presented here also provide an attractive empirical baseline in which outside directors provide advising benefits to the firm while at the same time preserving monitoring incentives. Recent studies in corporate governance[38] have suggested that there are persistent monitoring trade-off costs of hiring outside directors. The results here are very much consistent with those papers. For example, Fich and Shivdasani (2006) attributes director busyness (too many concurrent outside directorship positions) as a potential reason why outsiders may be poor monitors. My results point to the same conclusion. Directors with more outside directorship positions (identified as poor monitors that lead to worse governance outcomes), also on average diminish board heterogeneity when they join the board. These outside directors consequently do not benefit the firm from an advisory capacity nor are proper monitors in preserving shareholder rights.

5.3 Impact of Board Heterogeneity on Firm Strategic Policies: Net Investment and R&D Intensity

The prior section highlighted the growth of board heterogeneity since 2003 and that this increase in the demand for board heterogeneity may possibly be driven by each board's desire to acquire different industry expertise through it's outside directors. One noteworthy result was that of all performance measures of the firm, only Tobin's Q, a possible measurement of the firm's long-term growth opportunities, had any explanatory power on the firm's demand for heterogeneous directors. Here, I discuss the results of how changes in board heterogeneity may be the cause for long-run changes in two strategic corporate measures.

This section presents evidence that this increase in board heterogeneity has real effects on firms. Specifically, firms that increase board heterogeneity see positive increases to net investment rates and R&D rates.

[38]See Crifo and Roudaut (2017) and older papers such as Brick and Chidambaran (2005).

Identification is done with director deaths as the exogenous variation of board heterogeneity. There are 312 observed director deaths in the sample. Of the 15,573 firm-years, three firms had two director deaths in the same year[39]. Table 10. compares entering, exiting, and director deaths. Directors who pass away while in office tend to be older, tenured longer, independent directors, in smaller firms, and less R&D firms but the average director-board similarity scores are quite similar.

Table 11. presents the net investment intensity results. Column 1 and 3 are the first-stage regressions of the board heterogeneity based on director-board similarity score and the weighted director-board similarity score, respectively. Director deaths are exogenous events and unanticipated. Moreover, columns 1 and 3 indicate that director deaths significantly explain positive variations in board heterogeneity. When directors die, average board heterogeneity decreases (average directors become more similar) in part because the directors who die tend to be outside directors.

Columns 2 and 4 are the main 2SLS regression results. There is causal evidence that suggests that increases in board heterogeneity positively impacts net investment intensity. Not only is this statistically significant, but it is economically significant as well. A one standard deviation decrease of the similarity score equates to an increase of net investment intensity by roughly 8.4%. For a sense of scale, the death of Jobs' in 2012 increased the average director-board similarity score from 0.65 to 0.67. On average, the results presented here translate to roughly a 3% decrease in net investment intensity.

This is in line with results from Ellis, Fee and Thomas (2017) that find that outside advisors can positively impact net investment. However, the results here are more broadly applicable. Ellis, Fee and Thomas (2017)'s results apply only to conglomerates while here, all firms are considered. Of my sample of S&P 1,500 firms, nearly 40% of firms only report to one segment. Since Ellis, Fee and Thomas (2017) focus only on whether or not an outside director has segment industry expertise, their measured impact of the outside director might

[39]Brookline Bancorp Inc. 2008, South Jersey Industries Inc. 2009, and HMS Holdings Corp. 2009

be understated as it ignores all other industry expertise of the directors.

Panel C. shows similar results with respect to R&D intensity. I find that R&D intensity increases when boards become more heterogeneous. Likewise, a one standard deviation increase in board heterogeneity would equate to an average in crease of R&D intensity of 13.4%. In other word, the death of Jobs' would cause R&D intensity at Disney to decrease by approximately 4.5%.

This is consistent with Masulis et al. (2012) as well asFaleye, Hoitash and Hoitash (2017) who find that outside directors with prior industry experience are associated with greater innovation (patenting outcomes). The results are also consistent with Fan and Yang (2017) whose findings suggests that innovation direction and optimal technological space locations by firms are largely influenced by outside directors that join boards. Taken together, the results suggests that outside directors are understated advisors. These results are also consistent with the findings from the previous section that outside advisors with more different industry expertise are demanded by boards that have growth opportunities or are becoming increasingly more complex. Moreover, the contributions made by these outside directors have long-run strategic implications on firm direction as opposed to temporary short-term impacts on ROA or period-period returns.

5.4 Impact of Board Heterogeneity on Product Markets

In the prior section, I established causal evidence that board heterogeneity positively impacts net investment and R&D intensity. Since in a large part, board heterogeneity is the result of outside directors joining boards with more different industry expertise, it is the advising that these outside directors bring to the boards that affects the firm's long-term strategic decisions.

However, increased net investment and R&D expenditures may not be productive. Ellis, Fee and Thomas (2017) find empirical evidence that a "familiarity bias" exists whereby outside directors contribute to the internal politics of conglomerate firms by engaging in

inefficient allocations of firm resources to segments that the directors are experts in. This paper addresses a similar but broader question of whether outside directors provide a net benefit to the firm or not. I address this question though product market space placement as it is less subject to the uncertainties of other performance measures.

Table 11. panel C and D provides causal evidence again that shows that product differentiation increases when board heterogeneity increases. This is an important conclusion as it shows that firms actively seek out advisors with unique expertises and these expertises are leveraged by firms to increase investments and R&D, and finally these investments and R&D expenditures benefit the firm by allowing them to separate from their competitors. I show that this result holds when using two sources of product differentiation measures. The product market similarity score provides ex-post evidence of product differentiation by measuring revenues from segment sales. The second Hoberg-Phillips product differentiation score provides ex-ante evidence of product differentiation. Unlike the product market similarity score that utilizes revenues, the Hoberg-Phillips score captures the firm's intent in the product description. Therefore, the HP score captures product differentiation and the long-term direction of the firm.

6 Robustness

6.1 Segment Analysis

One possible channel in which increasing board heterogeneity can contribute to increased net investment and R&D intensity is that outside directors are hired by firms to advise the specific segments in which they are experts of and that this effect dominates in this sample. This is the explanation put forth by Ellis, Fee and Thomas (2017). To ensure that the results are not due to this conglomerate effect, I perform some subsample analysis based on the firm's product segments.

I divide the sample into single segment firms and firms that report two or more

segments of sales. Table 12. displays the first set of results of the subsample analysis on the demand determinant model. Column 1 is the results of estimating equation 6 but restricting the sample only to single segment firms. Column 2 is restricting the same model but to only firms with more than two segments. I find similar qualitative results between the two samples. In most cases, the coefficient magnitudes for multi-segment firms is slightly larger than that of the single-segment firm. However, I find no evidence to suggest that the demand determinants of board heterogeneity is exclusive to only single-segment firms.

Next, I consider net investment intensity and R&D intensity. Again, the subsample analysis shows roughly the same results as Table 9 panels A and B. Director deaths seem to be strong predictors of increases in board *similarity* from columns 1 and 3. This increase in board similarity then causes net investments and R&D to slow. Again, this effect is slightly more pronounced in conglomerate firms but still very much present in single segment firms.

For product differentiation, panel C performs the same analysis as Table 13. panel C. Since the product market similarity score is based on the similarities of segment sales shares, I use only the Hoberg-Phillips product differentiation score in this robustness test. For multi-segment conglomerate firms, product differentiation can mean emphasizing different product lines. However, for single segment firms, it is not clear what the change in product market similarity score implies especially if both firms are single-segment firms. Since the product market segment average product differentiation measure does not give a clear interpretation under this scenario, I only report the results based on the Hoberg-Phillips product differentiation score. The same results are largely the same. Table 13. Panel C dispays these results. I find that board heterogeneity leads to product differentiation, regardless of the number of product market segments the firm participates in.

In all, I do not find evidence that the conglomerate effect is impacting the results of the paper. I do find that board heterogeneity has the same qualitative impact (though smaller quantitative impact) on the firm's net investment and R&D intensity as well as increasing product differentiation.

6.2 Alternative Board Heterogeneity Specifications

The board heterogeneity measure used through out this paper (equation 1), emphasizes the similarity between the director's industry expertise and the board's industry expertise. However, an alternative way to consider board heterogeneity would be to consider how the board's industry expertise level varies over time. Board heterogeneity measured in this way, emphasizes less on the degree of industry expertise dispersion across the directors on the board, rather it focuses on the board entirely. It is important to note that board heterogeneity when specified this way, only changes when the board loses or gains an industry expertise and that industry expertise cannot be replicated by another board member. This formulation also discounts the effect of industry expertise stacking across its board members.

Since annual board industry expertises are a 1x12 vector, a similarity score can be calculated by comparing how the vector elements change over time. The same uncentered correlation measure is used to calculate the similarity score across time. Thus, board heterogeneity is alternatively calculated below:

$$B_{k,t-1,t} = \frac{B_{k,t}B'_{k,t-1}}{(B_{k,t}B'_{k,t-1})^{\frac{1}{2}}(B_{k,t}B'_{k,t-1})^{\frac{1}{2}}} \tag{15}$$

Here, a large similarity score implies that the industry expertise has remained very close to the same. For example, suppose an elected director to the board contributes all the same industry expertise that the board already has, the board similarity score would remain the same. This si not true under the previous measure of board heterogeneity. However, if the newly elected director brings to the board, an industry expertise that is entirely unique, then board similarity over time would decrease.

Table 14. displays the results of this alternative specification. Panel A. shows that the results still remain qualitatively the same under the new specification for board heterogeneity. Director deaths remain a significant instrumental variable as shown in columns 3 and 4. Columns 2 and 4 show that when directors die, exogenously increasing board similarity, this

increase board similarity decreases the net investment intensity and R&D intensity.

The results here indicate that gaining specific industry expertises matter at the board level. As firms gain expertise in other areas it previously did not have by electing directors with those expertise, it increases the intensities of net investment and R&D.

Next, in panel B, the results for the product differentiation are shown. The results are again consistent with the prior specifications for board heterogeneity. Similarly, the lack of advancement in board industry expertise causes product differentiation fo stagnant. This is true when measured by the product market similarity score and by the similarities in 10-K statements.

7 Conclusion

This paper begins by introducing three empirical facts that the corporate finance literature has largely ignored. First, outside directors have significant diverse industry expertise. This fact is inconsistent with the recent trend in the literature to focus very narrowly on specific director characteristics such as prior acquisition experience or same-industry expertise while assuming the director is homogeneous in all other facets. Second, board heterogeneity (average difference in the director's industry expertises) has increased over time. Directors are increasingly becoming more different from each other in terms of industry expertise. Third, board-level industry expertise has risen sharply over time. Whether the directors hired have more diverse expertise or firms have become more complex, the number of industry expertises that a corporate board has access to has grown steadily over time.

I introduce a simple methodology to construct director industry expertise vectors from prior employment data. This simple decomposition method then allows board expertise to be aggregated from the director expertise vectors. Using an uncentered correlation proximity measure based on Jaffe (1986), I can construct similarity score measures that compare how similar directors on a board are to each other and how similar a board is to itself over time.

I find that over the sample period 2003-2013, directors on the same board are becoming increasingly different in industry expertise offerings and the the same is also true at the board level.

I find that board heterogeneity is valued both by shareholders and the board. An event study using a matched sample of director-board connections describes an announcement return premium associated with the nomination of diverse industry expertise outside directors. This is only true and significant for outside directors with more diverse industry expertise than the board the director is joining and not true for more similar directors and inside executives who are promoted to the board.

I also find that at the board level, the demand for heterogeneous directors can be traced to both the increases in complexity of firms over time and the scope of the firm's business needs. Growth opportunities may also play an important role as well. Evidence points to a positive relationship between undervalued firms (low Tobin's Q) and the greater likelihood of hiring a different outside director, leading to more board heterogeneity

The increase in board heterogeneity over time has implications for the firm's major strategic policies and product market direction. Using unexpected director deaths as a source of exogenous variation in board heterogeneity, I show that increases in board heterogeneity increase net investment and R&D intensity. The results imply that a one standard deviation increase in board heterogeneity would on average increase net investment and R&D intensities by 8.4% and 13.4%, respectively. This result is consistent with many strands of literature that describe the outside director as an important advisor to the firm. I show that these increases in intensities are not a direct result of these outside directors inefficiently redirecting internal capital markets to their personal projects, rather the increases in board heterogeneity, net investment intensity, and R&D intensity result in firms product differentiating.

In all, the results of this paper show that the advise of outside directors play a very important role in the strategic planning by a firm. The results presented in this paper can

explain why despite all the empirical research on the benefits of hiring homogeneous outside directors, the evidence from press releases point to boards choosing outside directors with increasingly more diverse industry expertise instead.

References

Adams, Renée B., Benjamin E. Hermalin, and Michael S. Weisbach. 2010. "The Role of Boards of Directors in Corporate Governance: A Conceptual Framework and Survey." Journal of Economic Literature, 48(1): 58–107.

Aghion, Philippe, John Van Reenen, and Luigi Zingales. 2013. "Innovation and Institutional Ownership - Appendix." The American Economic Review, 103(1): 277–304.

Agrawal, Anup, and Charles R. Knoeber. 2001. "Do Some Outside Directors Play a Political Role?" The Journal of Law and Economics, 44(1): 179–198.

Agrawal, Anup, and Sahiba Chadha. 2005. "Corporate Governance and Accounting Scandals." The Journal of Law and Economics, 48(2): 371–406.

Albuquerque, Rui, and Jianjun Miao. 2013. "Ceo power, compensation, and governance." Annals of Economics and Finance, 14(2 A): 417–452.

Bharadwaj, Anandhi S. 2000. "A Resource-Based Perspective on Information Technology Capability and Firm." MIS Quarterly, 24(1): 169–196.

Bloom, Nicholas, Mark Schankerman, and John Van Reenen. 2013. "Supplement to "Identifying Technology Spillovers and Product market Rivalry"; Appendices." Econometrica, 81(4): 1347–1393.

Boone, Audra L., Laura Casares Field, Jonathan M. Karpoff, and Charu G. Raheja. 2007. "The determinants of corporate board size and composition: An empirical analysis." Journal of Financial Economics, 85(1): 66–101.

Borokhovich, Kenneth A, Robert Parrino, and Teresa Trapani. 1996. "Outside Directors and CEO Selection." The Journal of Financial and Quantitative Analysis, 31(3): 337–355.

Bozec, Richard, Mohamed Dia, and Yves Bozec. 2010. "Governance-performance relationship: A re-examination using technical efficiency measures." British Journal of Management, 21(3): 684–700.

Brick, Ivan E, and N.K. Chidambaran. 2005. "Board Monitoring and Firm Risk." Working Paper.

Brickley, James A., Jeffrey L. Coles, and Rory L. Terry. 1994. "Outside directors and the adoption of poison pills." Journal of Financial Economics, 35(3): 371–390.

Brown, Anna Bergman, Jing Dai, and Emanuel Zur. 2016. "The effect of director busyness on monitoring and advising: Evidence from a natural experiment." Working Paper.

Byrd, John W., and Kent A. Hickman. 1992. "Do outside directors monitor managers?. Evidence from tender offer bids." Journal of Financial Economics, 32(2): 195–221.

Cohen, Jeffrey, Udi Hoitash, Ganesh Krishnamurthy, and Arnold Wright. 2014. "The Effect of Audit Committee Industry Expertise on Monitoring the Financial Reporting Process." The Accounting Review, 89(1): 243–273.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen. 2008. "Boards: Does one size fit all?" Journal of Financial Economics, 87(2): 329–356.

Coles, Jeffrey L., Naveen D. Daniel, and Lalitha Naveen. 2012. "Board Advising." Working Paper.

Crifo, Patricia, and Gwenael Roudaut. 2017. "Board independence and the monitoring-advising trade-off." Working Paper.

Daily, C. M., and D. R. Dalton. 1997. "CEO and Board Chair Roles Held Jointly or Separately: Much Ado About Nothing?" Academy of Management Perspectives, 11(3): 11–20.

Dalziel, Thomas, Richard J. Gentry, and Michael Bowerman. 2011. "An Integrated Agency-Resource Dependence View of the Influence of Directors' Human and Relational Capital on Firms' R&D Spending." Journal of Management Studies, 48(6): 1217–1242.

Dass, Nishant, Omesh Kini, Vikram Nanda, Bunyamin Onal, and Jun Wang. 2014. "Board Expertise: Do Directors from Related Industries Help Bridge the Information Gap?" Review of Financial Studies, 27(5): 1533–1592.

Drobetz, Wolfgang, Felix Von Meyerinck, David Oesch, and Markus Schmid. 2017. "Industry Expert Directors." Working Paper.

Duchin, Ran, John G. Matsusaka, and Oguzhan Ozbas. 2010. "When are outside directors effective?" Journal of Financial Economics, 96(2): 195–214.

Ellis, Jesse A., C. Edward Fee, and Shawn Thomas. 2017. "Playing Favorites? Industry Expert Directors in Diversified Firms." Working Paper.

Fahlenbrach, Rudiger, Angie Low, and Rene M. Stulz. 2015. "Do independent director departures predict future bad events?" Working Paper.

Faleye, Olubunmi. 2014. "The costs of a (nearly) fully independent board." Journal of Empirical Finance, 32: 49–62.

Faleye, Olubunmi, Rani Hoitash, and Udi Hoitash. 2017. "Industry Expertise on Corporate Boards." Review of Quantitative Finance and Accounting, 48(4): 1–39.

Fan, Yang, and Mu-Jeung Yang. 2017. "Ties that Differentiate : How Board Networks shape Innovation and Competitive Positioning." Working Paper.

Fich, Eliezer M., and Anil Shivdasani. 2006. "Are Busy Boards Effective Monitors?" The Journal of Finance, 61(2): 689–724.

Fracassi, Cesare. 2017. "Corporate finance policies and social networks." Management Science Publication, 63(8): 2420–2438.

Fracassi, Cesare, and Geoffrey Tate. 2012. "External networking and internal firm governance." Journal of Finance, 67(1): 153–194.

Graham, John R., Hyunseob Kim, and Mark Leary. 2017. "CEO Power and Board Dynamics." Working Paper.

Henry, Darren. 2004. "Corporate governance and ownership structure of target companies and the outcome of takeovers." Pacific Basin Finance Journal, 12(4): 419–444.

Hermalin, Benjamin E., and Michael S. Weisbach. 1988. "Endogenously Chosen Boards of Directors and Their Monitoring of the CEO." The American Economic Review, 88(1): 96–118.

Hermalin, Benjamin E., and Michael S. Weisbach. 2003. "Boards Of Directors as an Endogenously Determined Institution: A Survey of the Economic Literature." Economic Policy Review, 9(1): 7–26.

Hoberg, Gerard, and Gordon Phillips. 2016. "Text-Based Network Industries and Endogenous Product Differentiation." Journal of Political Economy, 124(5): 1423–1465.

Hutchinson, Marion, and Ferdinand A. Gul. 2004. "Investment opportunity set, corporate governance practices and firm performance." Journal of Corporate Finance, 10(4): 595–614.

Jaffe, Adam B. 1986. "Technological Opportunity and Spillovers of R & D: Evidence from Firms' Patents, Profits, and Market Value." The American Economic Review, 76(5): 984–1001.

Jaffe, Adam B. 1988. "Demand and Supply Influences in R & D Intensity and Productivity Growth." The Review of Economics and Statistics, 3(3): 431–437.

Kim, Kyonghee, Elaine Mauldin, and Sukesh Patro. 2014. "Outside directors and board advising and monitoring performance." Journal of Accounting and Economics, 57(2-3): 110–131.

Li, Minwen, Yao Lu, and Gordon Phillips. 2016. "When are Powerful CEOs Beneficial ?" Working Paper.

Linck, James S., Jeffry M. Netter, and Tina Yang. 2008. "The determinants of board structure." Journal of Financial Economics, 87(2): 308–328.

Markarian, Garen, and Antonio Parbonetti. 2007. "Firm complexity and board of director composition." Corporate Governance, 15(6): 1224–1243.

Masulis, Ronald W., Christian Ruzzier, Sheng Xiao, and Shan Zhao. 2012. "Do Independent Expert Directors Matter?" Working Paper, 1–50.

McDonald, Michael L., James D. Westphal, and Melissa E. Graebner. 2008. "Services, industry evolution, and the copetitive strategies of product firms." Academy of Management Journal, 51(2): 315–334.

Minton, Bernadette A., Jérôme P. Taillard, and Rohan Williamson. 2014. "Financial Expertise of the Board, Risk Taking, and Performance: Evidence from Bank Holding Companies." Journal of Financial and Quantitative Analysis, 49(02): 351–380.

Mkrtchyan, Anahit, and Laura Casares Field. 2017. "The Effect of Director Expertise on Acquisition Performance." Journal of Financial Economics, 123(3): 488–511.

Nguyen, Bang Dang, and Kasper Meisner Nielsen. 2010. "The value of independent directors: Evidence from sudden deaths." Journal of Financial Economics, 98(3): 550–567.

Oehmichen, Jana, Sebastian Schrapp, and Michael Wolff. 2017. "Who Needs Experts Most? Board Industry Expertise and Strategic Change- A Contingency Perspective." Strategic Management Journal, 38(1): 315–334.

Shivdasani, Anil, and David Yermack. 1999. "CEO Involvement in the Selection of New Board Members : An Empirical Analysis." the Journal of Finance, 54(5): 1829–1853.

Tanriverdi, Hüseyin. 2005. "Information Technology Relatedness, Knowledge Management Capability, and Performance of Multibusiness Firms." MIS Quarterly, 29(2): 311–334.

Westphal, James D., and Edward J. Zajac. 1996. "Director Reputation, CEO-Board Power, and the Dynamics of Board Interlocks." Administrative Science Quarterly, 41(3): 507–529.

Appendix

7.1 Director, Board Expertise Vectors and Similarity Scores

In this section, I develop some of the theoretical foundations for the expertise vectors and similarity scores that are constructed.

Given a director 1 employed at board k at time t, the director's industry expertise vector is given by:

$$D_{1,t} = \{\ D_{1,1,t}, D_{1,2,t}, D_{1,3,t}...D_{1,n,t}\} \tag{16}$$

Similarly, director 2's industry expertise at time t is also a 1xn vector where n is the number of industry expertise subdivisions.This paper uses the Fama-French 12-Industry classification, thus n is 12. Prior papers have used other classifications such as the two-digit sic code.

$$D_{2,t} = \{\ D_{2,1,t}, D_{2,2,t}, D_{2,3,t}...D_{2,n,t}\} \tag{17}$$

Industry expertise similarity between director 1 and director 2 at time t is based on well-known Jaffe (1988) proximity measure or uncentered correlation of the vectors $D_{1,t}$ and $D_{2,t}$.

$$DD_{1,2,t} = \frac{D_{1,t}D'_{2,t}}{(D_{1,t}D'_{1,t})^{\frac{1}{2}}(D_{2,t}D'_{2,t})^{\frac{1}{2}}} \tag{18}$$

The proximity measure is a relative distance measure. This method of calculating the similarity score between two vectors is invariant to number of subdivisions in the categorization. To see this, if a broader categorization of industry is used it can causes more overlaps between industry expertises. Based on equation 14, the numerator might increase. However, a broader categorization also increases the denominator. Therefore, since the number of overlaps of subdivisions are normalized by the number of subdivisions, this proximity measure is invariant to the scale of industry classification[40].

The similarity measure has several attractive attributes. The similarity measure is 0 if two directors share no industry expertise and their industry expertises are orthogonal. The similarity measure is 1 if the directors exactly overlap in industry expertises. For similarity scores between 0 and 1, the similarity measure captures the degree of overlap of industry expertise; a higher similarity score indicates a greater degree of industry expertise overlap.

Director expertise vectors can be aggregated to the board-level expertise. Since director industry expertises are simply dummy variables, this paper considers a simple approach to board expertise, namely a board has expertise in an industry if one of the board members has expertise in that industry. Therefore, board expertise is also a 1x12 vector as in equation 4 with each element a 1 if a director on the board has expertise in that industry and 0 if no director has expertise[41].

[40] See also Bloom, Schankerman and Van Reenen (2013) Appendix C for a proof..

[41] In ongoing work, we allow board expertise to stack, where directors with overlapping expertises contribute to a larger expertise in an industry

$$B_{k,t} = \{\ B_{1,t}, B_{2,t}, B_{3,t}...B_{12,t}\} \tag{19}$$

where

$$B_{1,t} = \begin{cases} 1 & \text{if } \Sigma_i D_{i,1,t} > 0 \\ 0 & \text{if } \Sigma_i D_{i,1,t} = 0 \end{cases}$$

For some director D_1 that presides on board B_k at time t, the degree of industry expertise similarity between the director and the board is given by the same uncentered correlation equation 5. This director-board similarity score measure captures to what degree the director's industry expertises overlap with the board's expertises. In other words, this similarity score measures what a director can contribute that is unique to the board.

$$S_{k,i,t} = \frac{B_{k,t} D'_{1,t}}{(B_{k,t} B'_{k,t})^{\frac{1}{2}} (D_{1,t} D'_{1,t})^{\frac{1}{2}}} \tag{20}$$

An average director-board similarity score for a firm at time t can be calculated by averaging across all j incumbent directors of board k:

$$\overline{S_{k,t}} = \Sigma_i^j S_{k,i,t} \tag{21}$$

A change in the average director-board similarity score shows how board heterogeneity changes over time:

$$\Delta \overline{S_{k,t,t-1}} = \overline{S_{k,t}} - \overline{S_{k,t-1}} \tag{22}$$

For incoming director that will join a board at time t, similarity scores can also be found by comparing director and board industry expertise vectors at time $t-1$.

$$S_{k,i,t-1} = \frac{B_{k,t-1} F'_{1,t-1}}{(B_{k,t-1} B'_{k,t-1})^{\frac{1}{2}} (F_{1,t-1} F'_{1,t-1})^{\frac{1}{2}}} \tag{23}$$

7.2 Measuring Board Heterogeneity Based on Board Expertise Similarity

A second way that we can measure board heterogeneity focuses on the board's expertise. Board heterogeneity can also occur if boards desire to seek out directors to fill specific expertise needs.

Board expertise is a 1xn vector for n industries.

$$B_{k,t} = \{\ B_{1,t}, B_{2,t}, B_{3,t}...B_{n,t}\} \tag{24}$$

A board has industry expertise in an industry if at least one of its directors has expertise in that industry[42]. A board lacks expertise in an industry if no director on the board has expertise in that industry.

The similarity score of a board can be calculated across time, emphasizing the persistence (or lack of persistence) of board expertise on the board.

$$B_{k,t-1,t} = \frac{B_{k,t}B'_{k,t-1}}{(B_{k,t}B'_{k,t-1})^{\frac{1}{2}}(B_{k,t}B'_{k,t-1})^{\frac{1}{2}}} \tag{25}$$

[42]In ongoing work, we allow board expertise to stack, where directors with overlapping expertises contribute to a larger expertise in an industry

7.3 Constructing the Product Market Segment Score

Product differentiation can be implied by how firms derive revenue from multiple product market segments. For two competing firms, each firm may decide to emphasize sales into different product segments to decrease competition. As firms increasingly sell into more different product lines, the products offered between the two firms will differ, but increasing product differentiation.

To measure product differentiation, first we measure the product market segment score based on the similarity of revenue shares across market segments between two firms. Two firms are highly competitive if they derive similar revenue in the same market segments. The product market segment score generalizes this by comparing the revenue shares across all segments the firms sell into.

The product segment score is an adaptation of the Jaffe (1986) proximity measure used by Bloom, Schankerman and Van Reenen (2013) and Fan and Yang (2017). In the sample, I place no restriction product segments, thus generalizing the results of Ellis, Fee and Thomas (2017). In contrast to the Hoberg-Phillips score measure, this product measure accounts for ex-post product sales as opposed to the Hoberg-Phillips score that relies only on regulatory descriptions of products. As such, these two product measures provide two different perspectives on product market competition. Below we briefly describe the micro-foundations of the product market segment similarity score. Suppose firms compete in a unit product market space. Firms are positioned inside this unit space and the distance between any two firms measures the degree of competitiveness between the two firms based on the products that they sell. Consider two firms i and j that are inside the unit product market space.

The two firms i and j sell in to n product markets such that their revenue in each segment is $R_{it,n}$ and $R_{jt,n}$ at time t. In each product market segment that the firm earns revenue, the firm employs sales agents. The more overlapping sales agents two firms have in each segment, the more *competitive* the two firms are in that segment.

Firm i and firm j's sale shares at time t in n segments is a $1xN$ vector.

$$F_{i,t} = \{\ F_{1,t}, F_{2,t}, F_{1,t}...F_{n,t}\} \tag{26}$$

$$F_{j,t} = \{\ F_{1,t}, F_{2,t}, F_{1,t}...F_{n,t}\} \tag{27}$$

Firm i and firm j's proximity in a product market space can be approximated by the following uncentered correlation proximity measure:

$$PS_{i,j,t} = \frac{F_i F_j'}{(F_i F_i')^{\frac{1}{2}}(F_j F_j')^{\frac{1}{2}}} \tag{28}$$

Equation 19 calculates the product market similarity score between two firms, i and j at time t. If firms i and firm j derive revenue from very different product market segments, the product market similarity score will be small, indicating that the two firms are located far apart in the product market space. Similarity, if the product market similarity score is large, approaching one, firms i and firm j derive revenue from overlapping product market segments. This implies that the two firms are likely engaged in heavy competition.

The product market segment scores are based on the uncentered correlation proximity

measure. By construction, this measure is robust to aggregation[43]. In Bloom, Schankerman and Van Reenen (2013) and Fan and Yang (2017), the shares are based on 2-digit sic classifications. Here, the industries are based on Fama and French 12-Industries. This is used to match the industry classification of the director industry expertises.

Changes in the product market segment scores imply pair-wise changes in product differentiation. To measure broader product differentiation implications, I aggregate all pair-wise product market segment scores at the Fama-French 12 Industry level. This measures the average product differentiation for a firm against it's Fama-French 12 industry competitors. For some firm i in industry FF12=z at time t, the average product similarity score is given by equation 25.

$$PS_{i,FF=z,t} = \Sigma_j F_{i,FF=z,t}/j \tag{29}$$

To measure the change in product differentiation over time, one can measure the change in the average distance from equation 26.

$$\Delta PS_{i,FF=z,t} = PS_{i,FF=z,t} - PS_{i,FF=z,t-1} \tag{30}$$

[43]See Bloom, Schankerman and Van Reenen (2013) for a detailed analysis.

Table I

Director Employment History

This table contains current and prior employment data for S&P 1,500 directors between 2003-2013 that is obtained from the BoardEx Individual Profile Employment database. For non-board positions, industry expertise is obtained if the director worked in some officer capacity at the firm. Trade associations where the director may be a passive employee are not used. Non-Public firms refer to firms that do not issue securities. These firms include government entities, private universities, public universities, private firms, and nonprofit entities such as lobbying groups. The top 20 public and non-public firms that hire directors in our S&P 1500 sample of directors is shown below.

Public Firms	# **Employed**	**Non-Public Firms**	# **Employed**
I.B.M. Corp.	224	N.Y.S.E Inc	147
J.P. Morgan Chase	197	Harvard Business School	144
General Electric Co.	164	McKinsey&Co Inc.	128
AT&T Corp.	163	US Chamber of Commerce	128
Proctor&Gamble Co.	139	Arthur Andersen LLP	127
Bank of America Corp.	136	PriceWaterhouseCoopers	118
CitiGroup Inc.	127	National Institutes of Health	105
HP Inc.	121	Harvard University	99
Ford Motor Co.	115	Stanford University	93
Honeywell International	107	Ernst&Young LLP	90
Merrill Lynch&Co.	103	KPMG LLP	84
Motorola Inc.	102	M.I.T.	74
Goldman Sachs&Co.	101	Deloitte LLP	72
Morgan Stanley	92	Federal Reserve: N.Y.	72
Pepsico Inc.	88	U.S. Dept. of Energy	69
Microsoft Corp.	87	U.S. Senate	66
Xerox Corp.	77	U.S. S.E.C.	60
Coca-Cola Co.	74	Federal Reserve: Cleveland	60
Pfizer Inc.	72	Donaldson Lufkin&Jenrette	58
Johnson & Johnson	71	Kohlberg Kravis Roberts&Co.	54
8,752 Total Public Firms	62,212	18,929 Total Private Firms	50,700

Table II

Incoming Directors Characteristics

This table provides a summary of all incoming outside and incoming inside directors that join boards from 2004-2013. The summary statistics are based on the prior year before they join the board. Biographical data for directors (*age*, *female*) is obtained from the BoardEx Individual Profiles Details database and ISS Riskmetrics database. Education data comes from the BoardEx Individual Education database. A *Finance Degree* includes all undergraduate and graduate degrees related to finance that are not *MBA degrees*(These include degrees in accounting, economics, and financial engineering). The *Leadership* dummy implies that the director has managerial training either from an executive MBA program, certified managerial degrees, or other leadership type training. A director is a *Financial Expert* if the director has prior audit committee experience, was a certified accountant, has an MBA degree, or a graduate level degree in economics or finance. *Firm affiliation* was the total number of firms that a director was affiliated with. This is different from *Employed* positions as it also includes trade/craft affiliations. *FF12 Industry* is the number of different Fama-French 12-Industries the director is an expert in as an executive or higher capacity.

Variable	**All Directors**	**Outside Directors**	**Inside Directors**
Age	54.96	55.44	50.75
Female	0.170	0.181	0.076
MBA Degree	0.333	0.336	0.31
Finance Degree	0.113	0.112	0.12
Leadership	0.051	0.051	0.054
Financial Expert	0.625	0.59	0.51
Firm Affiliation	11.90	12.09	7.22
Employed	7.98	8.51	5.34
FF12 Industry	2.69	2.79	1.77
Similarity Score	0.48	0.49	0.45
Number of Observations	9,768	8,791	977

Table III

Firm Characteristics of Incoming Directors

This table describes the characteristics of firms that appoint directors from 2004-2013. This is a matched sample to the directors of Table II. and is based on prior connection year firm characteristics. S&P 1,500 firms are matched to BoardEx, Compustat, and CRSP data. *Num. Directors* refers to the number of board members annually. *Num. Independents* is the board-reported number of independent directors. *Ind. Adj. Return* is the prior two-year Fama-French 12-Industry adjusted return for the firms each year. *ROA* is the operating income before depreciation divided by book assets. *Tobin's Q* is the market value of assets divided by the book value of assets. The *Net Investment Intensity* and *R&D Intensity* is the annual net investment and R&D expenditures scaled by annual revenues each year. Annual similarity scores are based on $t-1$ similarity score between the incoming director industry expertise vector and the board expertise vector. The 25th, 50th, 75th quartiles are 0.378, 0.471, and 0.577 respectively.

Variable Name	**Mean**	**Director-Board Similarity Score**			
		1st Quartile	2nd	3rd	4th
Num. Directors	9.808	9.989	9.886	9.996	9.452
Num. Independents	7.887	8.069	7.979	8.0877	7.517
Ind.Adj. Return	-0.120	-0.111	-0.127	-0.124	-0.121
ROA	0.0380	0.0368	0.0420	0.0392	-0.0357
Tobin's Q	4.140	3.837	4.03010	4.170	4.455
Assets	36,883	36,380	39,736	31,064	37,219
Net Investment	3,558	3,568	3,649	3,855	3,264
Net Investment Intensity	0.420	0.420	0.426	0.421	0.415
R&D Expenditures	343	283	349	365	375
R&D Intensity	0.0802	0.0683	0.069	0.0899	0.0897
Number of Observations	9,768	2,711	1,734	2,327	2,996

Table IV

Panel A.

Steve Jobs Resume

This table provides a summary of Steve Job's employment that is obtained from BoardEx Employment Data. *Industry* and *FF12* classification variables are based on the Fama and French 12-Industry classification of industry. The list is organized by the employer and includes the entire duration of the tenure. Only the last role is displayed in the sample.

Employer	Date Start	Date End	Role	Industry	SIC	FF12
HP Inc.	1968	1970	Employee	Information Technology Hardware	3570	6
Atari	1974	1976	Employee	Media&Entertainment	7994	12
Apple Inc.	1976	1985	Co-Founder	Information Technology Hardware	3571	6
NeXt Computer	1985	1997	Co-Founder	Software&Computer Services	3571	6
Apple Inc.	Aug-97	Jan-00	Interim CEO	Information Technology Hardware	3571	6
Apple Inc.	Jan-00	Aug-11	CEO, Executive Officer, Co-Founder	Information Technology Hardware	3571	6
Apple Inc.	Aug-11	Oct-11	Chairman	Information Technology Hardware	3571	6
Gap Inc.	Sep-99	Jan-02	Director-SD	General Retailers	5651	9
Pixar Inc.	Mar-91	May-06	Chairman/CEO, Co-Founder	Media&Entertainment	7812	12
Walt Disney	May-06	Oct-11	Director-SD	Media&Entertainment	4841	12

Panel B.

Steve Jobs Industry Expertise Vectors

This table provides a summarizes how to de-construct Steve Job's prior employment data from Panel A in a 1x12 industry expertise vector. For example, in 1995, Steve Jobs has industry expertise in Fama-French 12-Industry category 6 (Business Equipment - Computers, Software, and Electronic Equipment) and Fama-French 12-Industry category 12 (Other -Entertainment).

Year	Director	Fama-French 12-Industry Categories											
1995	Steve Jobs	0	0	0	0	0	1	0	0	0	0	0	1
2000	Steve Jobs	0	0	0	0	0	1	0	0	1	0	0	1
2005	Steve Jobs	0	0	0	0	0	1	0	0	1	0	0	1

Table V

Board of Walt Disney Holdings Co. 2005

This table lists the 2005 12-member board of The Walt Disney Holdings Co. Each director's official board position, name, primary firm/role is displayed below. There are ten independent directors out of the twelve. Each director's resume is used to create the annual industry expertise vector based on Fama-French 12-Industry classifications. The board's expertise (Walt Disney) is determined by whether a member director has expertise. If the a director has expertise in one of the Fama-French 12-Industries, it is assumed that the board also has expertise in that industry, For 2005, the board has expertise in all industries except industry two. Since no board member has industry expertise in Fama-French 12-Industry category 2 (Consumer Durables – Cars, TV's, Furniture, Household Appliances), the board has no industry expertise in category 2 as well.

Director*	Fred Langhammer	Estee Lauder Chairman	1	0	0	0	0	0	0	0	1	0	1	1
Director*	Aylwin Lewis	Sears Holding CEO	1	0	0	1	0	0	0	0	1	0	0	1
Director*	Judy Estrin	Packet Design Inc CEO	0	0	0	0	0	1	0	0	0	0	1	1
Director*	Gary Wilson	Northwest Air. Chairman	0	0	0	0	0	1	0	0	0	0	1	1
Chairman*	George Mitchell Jr	Former US Senator	1	0	0	0	0	1	0	1	1	0	1	1
Director*	Leo O'Donovan	Pres. of Georgetown Univ.	0	0	0	0	0	0	0	0	0	0	0	1
Director*	John Chen	Sybase Inc Chairman/Pres.	0	0	0	0	0	1	0	0	0	0	1	1
Pres./CEO	Bob Iger	Disney President/CEO	0	0	1	0	0	0	0	0	0	0	1	1
Director	John Bryson	Edison Intl. Chairman	1	0	1	0	0	0	0	1	0	0	1	1
Director*	Robert Matschullat	Clorox Company Chairman	1	0	0	0	1	0	1	0	0	1	1	1
Director*	Lisa Pitney	CA Chamber of Commerce	0	0	0	0	0	0	0	0	0	0	0	1
Director*	Monica Lozano	La Opinion Magazine CEO	0	0	0	0	0	0	0	0	0	1	1	1
	Board Expertise		1	0	1	1	1	1	1	1	1	1	1	1

**Independent*

Table VI

Number of Total Industry Expertises on a Board

This table provides a summary of the total number of industries that a firm has expertise in. Expertise are based on Fama-French 12-Industry classification. The board has expertise in an industry if a board member has expertise in that industry. For example, a value of five indicates that the firm has expertise in five of the twelve FF12 industries. Column 2 is the entire sample 2003-2013. Columns 3-5 are for years 2003, 2008, and 2013, respectively. A Wilcoxon Rank-Signed test rejects the null that the number of total FF12 industries on average for each firm is constant throughout the sample.

Number of Total FF12 Industries	**2003-2013**	**2003**	**2008**	**2013**
1	15	2	2	0
2	223	26	24	18
3	702	73	59	50
4	1,214	127	118	89
5	1,549	151	134	141
6	2,046	211	178	159
7	2,247	194	218	205
8	2,284	177	205	235
9	2,242	163	211	218
10	1,723	138	163	178
11	1,004	82	78	107
12	324	24	30	34
Mean	7.31***	7.03	7.29	7.56
Standard Deviation(std.)	2.35	2.39	2.34	2.30
Median	7.00	7.00	7.00	8.00
7.31	15,573	1,368	1,420	1,434

*** A Wilcoxon Signed Rank test t for the mean = -6.440
p-value=0.00

Table VII

Director-Board Similarity Score

This table provides a summary of the total number of industries that a firm has expertise in. Expertise are based on Fama-French 12-Industry classification. The board has expertise in an industry if a board member has expertise in that industry. For example, a value of five indicates that the firm has expertise in five of the twelve FF12 industries. Column 2 is the entire sample 2003-2013. Columns 3-5 are for years 2003, 2008, and 2013, respectively. A Wilcoxon Rank-Signed test rejects the null that the number of total FF12 industries on average for each firm is constant throughout the sample.

Year	Director-Board Similarity Score	Obs.	Std.	Median
2003	0.675	1,368	0.0967	0.669
2004	0.671	1,398	0.0956	0.665
2005	0.667	1,396	0.0942	0.657
2006	0.665	1,400	0.0948	0.654
2007	0.661	1,388	0.0930	0.654
2008	0.660	1,419	0.0954	0.651
2009	0.659	1,447	0.0960	0.648
2010	0.656	1,419	0.0973	0.643
2011	0.652	1,445	0.0969	0.639
2012	0.651	1,450	0.100	0.640
2013	0.645	1,434	0.0995	0.634
Mean	0.660***	15,564	0.0967	0.650

***A Wilcoxon Signed Rank test t for the mean = -8.440
p-value=0.00

Table VIII

Shareholder Gains from Announcement Returns

This table displays the results of the event study of announcements of incoming directors. Cumulative abnormal returns are calculated based on an estimation window of [-210,-40] and event window of [-4,+1]. The market return is based on the Value-Weighted CRSP return. Incoming directors are from S&P 1500 firms from 2003-2013. An initial sample of 8,995 directors are matched with announcement dates from BoardEx. Directors announcements are excluded if they coincide with earnings announcements, executive/board turnovers, mergers/acquisitions, and other events such as litigations, product recalls, FDA product statements..etc.

	Obs.	**Mean**	**t-Statistic**	**%>0**
All Directors	1301	0.00282**	3.03	51%
Directors(outsiders)<Median	550	0.00447**	2.78	59%
Directors(outsiders)>Median	751	0.00100	1.56	51%
Directors(insiders) <Median	81	-0.00276	-0.71	50%

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table IX

The Demand for Board Heterogeneity: Incoming Directors

This table describes the result of model 5. The dependent variable is the similarity score between the incoming director and the board's industry expertise based on equation 1. All incoming directors are outside directors who do not become CEOs of the target firm. *CEO Tenure* is log of the CEO's tenure in years. *CEO-Chair Dual Title* is a dummy variable that is 1 if the current CEO is also the chairman and 0 if not. *Weak Connection* and *Strong Connection* are dummy variables that are 1 if social networking ties exist between the incoming director and the board members. *Weak Connection* are connections that are based are a weaker set of criteria to establish a connection, namely degree attainment at same school within four years and any position in other outside activities (See the methodology section for a more detail summary). % *Independent* is the percentage of incumbent board members who are classified as independent. *CEO < 1 Year* is a dummy variable that is 1 if the current CEO has been in the role for less than one year. *Board Size* is the log of the number of directors on the board. *# of Segments* is the number of Fama-French 12-Industry segments that the firm derives revenue from.

	(1)	(2)	(3)	(4)	(5)
BOARD Characteristics					
CEO Tenure	-0.00398	0.00367	0.00379	0.00352	-0.00443
	(-1.69)	(1.72)	(1.85)	(1.69)	(-1.87)
CEO-Chair Dual Title	0.00507	-0.00748*	-0.00678*	-0.00786*	0.00464
	(1.24)	(-2.04)	(-1.98)	(-2.22)	(1.13)
Weak Connection	0.0454***	0.0271***	0.0275***	0.0275***	
	(11.87)	(7.95)	(8.32)	(8.27)	
Strong Connection					0.0330***
					(9.34)
% Independent	0.0181	-0.0808***	-0.0893***	-0.0880***	0.0197
	(0.93)	(-4.38)	(-5.03)	(-4.91)	(1.02)
CEO <1 Year	-0.00249	0.00317	0.00243	0.00234	-0.00238
	(-0.41)	(0.57)	(0.45)	(0.43)	(-0.39)
Board Size		-0.0473***	-0.0518***	-0.0516***	
		(-6.23)	(-7.31)	(-7.22)	
FIRM Characteristics					
# of Segments		-0.00434***	-0.00433***	-0.00439***	
		(-3.63)	(-3.76)	(-3.80)	
Total Industry Expertise	-0.0824***				-0.0846***
	(-11.93)				(-12.17)
Tobin's Q	0.00103***	0.000797**			0.00109***
	(2.72)	(2.83)			(2.88)
ROA			-0.251		
			(0.185)		
Industry Excess Return				0.00210	
				(1.08)	
Overlapping Expertise	0.0909***	0.107***	0.107***	0.107***	0.0912***
	(25.45)	(32.85)	(33.85)	(33.70)	(25.46)

Table IX Continued

The Demand for Board Heterogeneity: Incoming Directors

Total Industry Expertise is the total number of industry expertise of the board based on equation 15. The performance measures *Tobin's Q*, *ROA*, and *Industry Excess Return* are operating income before depreciation divided by book assets, the market value of assets divided by the book value of assets, and the CRSP two-year prior industry-adjusted return, respectively. *Same Industry Expertise* is a dummy variable that is 1 if the incoming director is an industry expert of the primary FF12 industry of the firm. For director characteristics, *Total Board Membership* is the total number of other current board positions that the director is active in. This includes all listed and unlisted firms. *SP1500 Committee EXP* is a dummy variable that is 1 if the director has prior committee experience (nomination, executive, audit, corporate governance) at a S&P 1,500 firm. *Chairman* is a dummy that is 1 if the director's role is a chairman when hired. *Age* is the log of the director's age in years. *Female* is a dummy variable that is 1 if the director is a female. Finally, *MBA Degree* is a dummy that is 1 if the director holds an MBA degree the year before joining the board of the firm.

	(1)	(2)	(3)	(4)	(5)
DIRECTOR Characteristics					
Total Board Membership	0.0290***	0.0140***	0.0133***	0.0134***	0.0286***
	(13.44)	(7.15)	(7.03)	(7.05)	(13.20)
SP1500 Committee EXP	0.0632***	0.00558	0.00515	0.00520	0.0649***
	(14.19)	(1.37)	(1.30)	(1.30)	(14.57)
Chairman	0.109	-0.0143	-0.00607	-0.00435	0.0103
	(0.25)	(-0.40)	(-0.19)	(-0.13)	(0.25)
Age	0.0289**	0.0194	0.0166	0.0171	0.0250
	(2.19)	(1.58)	(1.41)	(1.45)	(1.89)
Female	0.0129**	0.00148	0.000539	-0.00296	0.117**
	(2.90)	(0.37)	(0.14)	(-0.08)	(2.64)
MBA Degree	0.0146***	0.000568	0.0000	-0.0000367	0.0158***
	(3.93)	(0.17)	(-0.00)	(-0.01)	(4.24)
Constant	0.414***	0.379***	0.409***	0.407***	0.429***
	(7.26)	(7.02)	(8.04)	(7.96)	(7.49)
FIXED EFFECTS					
Fama-French 12-Industry	YES	YES	YES	YES	YES
Year	YES	YES	YES	YES	YES
Observations	6,548	6,548	6,997	6,935	6,548

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table X

Comparisons of Director: Entrants, Exits, and Deaths

This table provides a summary of directors that join boards, resign, or vacate due to death. *Entering directors* are directors that join a board for the first time. *Exiting directors* are directors that are no longer in the firm the following year and the firm continues to be listed for at least two years. *Director Death* refers to directors who die while still director serving the board.

Variable	**Entering Director**	**Exiting Director**	**Director Death**
Time in Board	0.572	10.536	13.754
Time in Company	1.643	11.778	14.433
Age	56.005	63.73	70.129
CEO	0.0884	0.0805	0.0609
Chairman	0.0176	0.102	0.167
Executive	0.111	0.0921	0.0192
Independent Director	0.829	0.736	0.817
Dir-Firm Sim Score	0.59	0.586	0.597
Excess Return	-0.00808	-0.103	-0.0938
Assets	39,890.68	42,583.09	18,096.66
R&D	350.591	351.818	208.5912
Net Investment	3,789.092	3,791.411	2,176.21
Number of Observations	9,941	9,881	312

Table XI

Panel A

Board Heterogeneity, Director Deaths, and Net Investment Intensity

This table displays the 2SLS regression of the model presented in Equation 6-7. *Director Deaths* is a discrete variable that can take on the values of 0,1, or 2 which are the total possible annual director deaths in a firm from 2003-2013. *Ind. Adj. Return* is the Fama-French 12-Industry adjusted prior two-year return for the firm. *Number of Directors* and *Number of Independents* refer to the number of directors on the board for that year and the number of stated independent directors on the board for that year. *Total Assets* is the natural log of the prior year's Total Asset for the firm. In columns 1 and 3 are the first stage regression of the 2SLS. Column 1 is the board heterogeneity measure based on the change in similarity score of directors and board industry expertise. Column 3 is board heterogeneity weighted by board size. Columns 2 and 4 are the 2SLS regressions. The dependent variable of columns 2 and 4 are the change in net investment intensity.

	Δ Dir.-Firm First-Stage	**ΔNet Invest. Intensity**	**Δ Dir.-Firm First-Stage (Weighted)**	**ΔNet Invest. Intensity (Weighted)**
Director Deaths	0.00570***		0.000700***	
	(8.31)		(9.59)	
Δ Director-Firm		-1.318***		
		(-5.73)		
Δ Director-Firm (weighted)				-30.526***
				(-5.44)
Avg. Age of Directors	-0.00862***	0.444***		
	(-30.93)	(215.37)		
Number of Directors	0.0169***	0.0321***	0.000348***	0.755***
	(18.83)	(7.53)	(3.77)	(141.98)
Number of Independents	0.000833	0.00544***	0.000342***	-0.0772***
	(0.98)	(3.73)	(3.43)	(-14.67)
Ind. Adj. Return	-0.00147***	-0.0180***	-0.000133***	-0.0115***
	(-9.02)	(-3.87)	(-6.44)	(-8.65)
Total Assets	-0.000973***	-0.00299**	-0.000121***	-0.00902***
	(-12.76)	(-10.43)	(-14.80)	(-10.80)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	12,517	12,517	12,517	12,517

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XI

Panel B

Board Heterogeneity, Director Deaths, and R&D Intensity

This table displays the 2SLS regression of the model presented in Equation 8-9. *Director Deaths* is a discrete variable that can take on the values of 0,1, or 2 which are the total possible annual director deaths in a firm from 2003-2013. *Ind. Adj. Return* is the Fama-French 12-Industry adjusted prior two-year return for the firm. *Number of Directors* and *Number of Independents* refer to the number of directors on the board for that year and the number of stated independent directors on the board for that year. *Total Assets* is the natural log of the prior year's Total Asset for the firm. In columns 1 and 3 are the first stage regression of the 2SLS. Column 1 is the board heterogeneity measure based on the change in similarity score of directors and board industry expertise. Column 3 is board heterogeneity weighted by board size. Columns 2 and 4 are the 2SLS regressions. The dependent variable of columns 2 and 4 are the change in R&D intensity.

	Δ Dir.-Firm First-Stage	**ΔR&D Intensity**	**Δ Dir.-Firm First-Stage (Weighted)**	**ΔR&D Intensity (Weighted)**
Director Deaths	0.00722***		0.000781***	
	(6.11)		(5.52)	
Δ Director-Firm		-2.0859***		
		(-5.60)		
Δ Director-Firm (weighted)				-11.241***
				(-6.02)
Avg. Age of Directors	-0.00992***	0.547***		
	(-27.41)	(143.68)		
Number of Directors	0.0195***	0.0464***	0.000450**	0.0330***
	(14.62)	(5.68)	(3.01)	(7.76)
Number of Independents	0.00261*	0.0159***	0.000488**	0.00576***
	(2.08)	(4.51)	(3.15)	(3.99)
Ind. Adj. Return	-0.000575***	0.000767	-0.000052*	-0.00156***
	(-2.80)	(0.99)	(-1.94)	(-3.62)
Total Assets	-0.00158***	-0.00437***	-0.000169***	-0.00317***
	(-17.03)	(-6.72)	(-15.30)	(-10.55)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	7,102	7,102	7,102	7,102

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XI

Panel C

Board Heterogeneity, Director Deaths, and Average Product Market Similarity Score

This table displays the 2SLS regression of the model presented in Equation 10-11. *Director Deaths* is a discrete variable that can take on the values of 0,1, or 2 which are the total possible annual director deaths in a firm from 2003-2013. *Ind. Adj. Return* is the Fama-French 12-Industry adjusted prior two-year return for the firm. *Number of Directors* and *Number of Independents* refer to the number of directors on the board for that year and the number of stated independent directors on the board for that year. *Total Assets* is the natural log of the prior year's Total Asset for the firm. In columns 1 and 3 are the first stage regression of the 2SLS. Column 1 is the board heterogeneity measure based on the change in similarity score of directors and board industry expertise. Column 3 is board heterogeneity weighted by board size. Columns 2 and 4 are the 2SLS regressions. The dependent variable of columns 2 and 4 are the change in the Average Product Market Similarity Score.

	ΔDir.-Firm First-Stage	**ΔProduct Mkt Segment Score**	**ΔDir.-Firm First-Stage (Weighted)**	**ΔProduct Mkt Segment Score (Weighted)**
Director Deaths	0.00799***		0.000839***	
	(9.36)		(8.69)	
Δ Director-Firm		0.206**		
		(3.25)		
Δ Director-Firm (weighted)				1.961**
				(3.22)
Avg. Age of Directors	-0.00975***	-0.00975***		
	(-29.66)	(-29.66)		
Number of Directors	0.0178***	0.0178***	0.000193	0.000406
	(16.56)	(16.56)	(1.79)	(0.82)
Number of Independents	0.00317**	0.00317**	0.000599***	-0.00191**
	(3.18)	(3.18)	(5.13)	(-3.15)
Ind. Adj. Return	-0.00122***	-0.00122***	-0.000135***	0.000630***
	(-6.70)	(6.70)	(-5.76)	(5.24)
Total Assets	-0.00116***	-0.00116***	-0.000134***	0.000099
	(-14.38)	(-14.38)	(-14.47)	(0.91)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	9,062	9,062	9,062	9,062

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XI

Panel D

Board Heterogeneity, Director Deaths, and Average Product Differentiation Score

This table displays the 2SLS regression of the model presented in Equation 12-13. *Director Deaths* is a discrete variable that can take on the values of 0,1, or 2 which are the total possible annual director deaths in a firm from 2003-2013. *Ind. Adj. Return* is the Fama-French 12-Industry adjusted prior two-year return for the firm. *Number of Directors* and *Number of Independents* refer to the number of directors on the board for that year and the number of stated independent directors on the board for that year. *Total Assets* is the natural log of the prior year's Total Asset for the firm. In columns 1 and 3 are the first stage regression of the 2SLS. Column 1 is the board heterogeneity measure based on the change in similarity score of directors and board industry expertise. Column 3 is board heterogeneity weighted by board size. Columns 2 and 4 are the 2SLS regressions. The dependent variable of columns 2 and 4 are the change in the Average Product Differentiation Score. The Product Differentiation Score is based on the Hoberg-Phillips Product Differentiation score from firm's annual 10-Ks.

	ΔDir.-Firm First-Stage	**ΔProduct Differentiation**	**ΔDir.-Firm First-Stage (Weighted)**	**ΔProduct Differentiation (Weighted)**
Director Deaths	0.00602***		0.000697***	
	(7.08)		(7.70)	
Δ Director-Firm		0.203***		
		(4.65)		
Δ Director-Firm (weighted)				1.754***
				(4.86)
Avg. Age of Directors	-0.00915***	0.00202***		
	(-29.39)	(4.95)		
Number of Directors	0.0169***	-0.00255**	0.000228*	0.000745**
	(16.47)	(-3.16)	(2.22)	(2.93)
Number of Independents	0.00263**	-0.00158***	0.000581***	-0.00210***
	(2.75)	(-6.01)	(5.24)	(-6.76)
Ind. Adj. Return	-0.00119***	0.000515***	0.000133***	0.000507***
	(-6.65)	(7.38)	(-5.82)	(7.36)
Total Assets	-0.00114***	0.000283***	-0.000143***	0.000301***
	(-14.85)	(5.00)	(-16.46)	(5.15)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	9,846	9,846	9,846	9,846

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XII

Robustness: Segment Analysis- Demand for Heterogeneous Directors

This table is the subsample analysis of Table 9. column 1. The dependent variable is the $t-1$ director-board similarity score. Column 1 restricts the sample only to firms that report one segment of sales. Column 2 restricts the sample to only firms that report more than one segment of sales. *Social Networking Connection* is based on the weaker criteria of creating a potential link between the director and the board.

	Single Segment Director-Board Score	**2 or more Segments Director-Board Score**
CEO Tenure	-0.00621	-0.00267
	(-1.46)	(-0.94)
CEO-Chair Dual Title	0.00101	0.000955
	(1.42)	(0.19)
Social Networking Connection	0.0413***	0.0468***
	(5.92)	(10.25)
% Independent	0.00308	0.0248
	(0.09)	(1.05)
CEO <1 Year	-0.00682	-0.000231
	(-0.62)	(-0.03)
Total Industry Expertise	-0.0977***	-0.0745***
	(-8.64)	(-8.36)
Tobin's Q	0.000413**	0.00121**
	(2.63)	(2.57)
Overlapping Expertise	0.0902***	0.0929***
	(13.65)	(21.71)
Total Board Membership	0.0290***	0.0319***
	(13.44)	(12.43)
SP1500 Committee EXP	0.063***	0.0622***
	(7.58)	(11.80)
Chairman	-0.0459	0.0363
	(-0.63)	(0.73)
Age	0.00974	0.0391*
	(0.44)	(2.38)
Female	0.0100	0.000539
	(1.21)	(0.14)
MBA Degree	0.0149*	0.0145**
	(2.21)	(3.27)
Constant	0.527***	0.0.355***
	(5.49)	(5.00)
Fama-French 12-Industry	YES	YES
Year	YES	YES
Observations	6,548	6,997

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIII

Panel A

Robustness: Segment Analysis- Net Investment Intensity

This table displays the robustness analysis of the effect of the number of segments on the results of Table XI Panel A. Columns 1 and 3 are the first-stage regressions of the 2SLS. Columns 3 and 4 are the 2SLS regressions themselves. The dependent variable for columns 3 and 4 is the change in net investment intensity between time $t+2$ and $t+1$.

	Single Segment		**2 or more Segments**	
	First-Stage	**ΔNet Invest. Intensity**	**First-Stage**	**ΔNet Invest. Intensity**
Director Deaths	0.00971***		0.00447***	
	(7.67)		(5.54)	
Δ Director-Firm		-1.0672***		-1.396***
		(-5.05)		(-3.98)
Avg. Age of Directors	-0.00881***	0.447***	-0.00890***	0.441***
	(-14.64)	(215.47)	(-29.19)	(135.28)
Number of Directors	0.0178***	0.0391***	0.0172***	0.0309***
	(10.21)	(8.43)	(16.32)	(4.74)
Number of Independents	-0.00313*	-0.0996***	0.00240***	0.0116***
	(-1.94)	(-3.88)	(2.40)	(5.96)
Ind. Adj. Return	-0.00232***	-0.0310***	-0.00113***	-0.00109*
	(-6.64)	(-4.18)	(-6.25)	(-1.96)
Total Assets	-0.000162	-0.00178***	-0.00125***	-0.00338***
	(-0.82)	(-6.64)	(-16.24)	(-6.80)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	3,555	3,555	8,962	8,962

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIII

Panel B

Robustness: Segment Analysis- R&D Intensity

This table displays the robustness analysis of the effect of the number of segments on the results of Table 11 Panel B. Columns 1 and 3 are the first-stage regressions of the 2SLS. Columns 3 and 4 are the 2SLS regressions themselves. The dependent variable for columns 3 and 4 is the change in R&D intensity between time $t+2$ and $t+1$.

	Single Segment		**2 or more Segments**	
	First-Stage	**ΔR&D Intensity**	**First-Stage**	**ΔR&D Intensity**
Director Deaths	0.00568*		0.00807***	
	(2.03)		(6.82)	
Δ Director-Firm		-3.771*		-1.620**
		(-1.95)		(-6.03)
Avg. Age of Directors	-0.00882***	0.537***	-0.0105***	0.549***
	(-13.11)	(30.85)	(-23.99)	(187.99)
Number of Directors	0.0203***	0.0894*	0.0187***	0.0308***
	(8.93)	(2.17)	(11.21)	(5.12)
Number of Independents	-0.000975	0.000827	0.00495**	0.0218***
	(-0.47)	(0.09)	(3.11)	(6.48)
Ind. Adj. Return	-0.00194***	0.00107	0.000010	-0.000325*
	(-5.45)	(0.25)	(0.04)	(-0.65)
Total Assets	-0.00140***	-0.00652*	-0.00169***	-0.00350***
	(-7.14)	(-2.23)	(-15.67)	(-6.94)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	2,275	2,275	4,827	4,827

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIII

Panel C

Robustness: Segment Analysis- Average Product Differentiation (Hoberg-Phillips Score)

This table displays the robustness analysis of the effect of the number of segments on the results of Table 9. Panel D. Columns 1 and 3 are the first-stage regressions of the 2SLS. Columns 3 and 4 are the 2SLS regressions themselves. The dependent variable for columns 3 and 4 is the change in the Hoberg-Phillips Product Differentiation score between time $t+2$ and $t+1$. The product differentiation scores are aggregated at each firm's Fama-French 12-Industry level.

	Single Segment		**2 or more Segments**	
	First-Stage	**ΔProduct Differentiation**	**First-Stage**	**ΔProduct Differentiation**
Director Deaths	0.00837***		0.00487***	
	(4.55)		(5.12)	
Δ Director-Firm		0.101*		0.262***
		(2.10)		(3.91)
Avg. Age of Directors	-0.00904***	0.000599	-0.00807***	0.00273***
	(-16.63)	(1.34)	(-26.44)	(4.23)
Number of Directors	0.0170***	-0.00136	0.0150***	-0.00335**
	(9.37)	(-1.56)	(12.92)	(-2.68)
Number of Independents	0.00257	-0.000384	0.00324**	-0.00212***
	(1.51)	(-1.23)	(2.92)	(-5.43)
Ind. Adj. Return	-0.00131***	0.000256**	-0.00141***	0.000618***
	(-3.64)	(3.11)	(-6.85)	(5.87)
Total Assets	-0.00108***	0.000258***	-0.00138***	0.000310***
	(-7.26)	(3.45)	(-16.08)	(3.88)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	2,902	2,902	6,944	6,944

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIV

Panel A

Alternative Board Heterogeneity: Board Industry Expertise Similarity

This table displays uses an alternative specification for board heterogeneity. Board heterogeneity is based on year-to-year changes of board-level industry expertise differences.

	ΔBoard Expertise First-Stage	**ΔNet Invest. Intensity**	**ΔBoard Expertise First-Stage**	**ΔR&D Intensity**
Director Deaths	0.0198***		0.0163***	
	(13.34)		(6.21)	
ΔBoard Expertise		-0.315***		-0.895***
		(-6.82)		(-5.62)
Avg. Age of Directors	0.00380***	-0.456***	0.00186*	0.570**
	(5.58)	(1033.67)	(2.01)	(520.60)
Num. Directors	0.00181	0.00970***	-0.00191	0.00158
	(0.85)	(7.85)	(-0.60)	(0.40)
Num. Independents	-0.000785***	0.00160	-0.00491	0.00656
	(-3.88)	(1.26)	(-1.55)	(1.72)
Ind. Adj. Return	0.00156***	0.000688*	0.00167**	0.00367***
	(3.89)	(2.36)	(3.21)	(4.03)
Total Assets	0.000267	-0.00156***	0.000713**	-0.000238
	(1.50)	(-8.04)	(3.08)	(-0.80)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	10,920	10,920	6,195	6,195

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table XIV

Panel B

Alternative Board Heterogeneity: Board Industry Expertise Similarity

This table displays uses an alternative specification for board heterogeneity. Board heterogeneity is based on year-to-year changes of board-level industry expertise differences.

	ΔBoard Expertise First-Stage	**ΔProduct Segment Score**	**ΔBoard Expertise First-Stage**	**ΔProduct Differentiation Score**
Director Deaths	0.0214***		0.0233***	
	(11.88)		(13.65)	
ΔBoard Similarity		0.0764**		0.0516***
		(3.29)		(5.71)
Avg. Age of Directors	0.00172***	-0.000482**	0.00344***	-0.000033
	(4.18)	(-2.49)	(4.85)	(-0.43)
Number of Directors	0.0000962	0.00108	0.00215	0.000792***
	(0.49)	(1.89)	(0.97)	(3.60)
Number of Independents	-0.00726**	-0.000186	-0.00896***	-0.000550**
	(-3.48)	(0.34)	(-4.33)	(-2.65)
Ind. Adj. Return	0.00172***	0.000225*	0.00185***	0.000163***
	(4.18)	(2.20)	(4.52)	(4.16)
Total Assets	0.000550**	-0.000212**	0.000647***	0.0000009
	(3.13)	(-2.93)	(3.60)	(0.40)
Fixed Effects				
Fama-French Industry	YES	YES	YES	YES
Year	YES	YES	YES	YES
Observations	9,054	9,054	9,822	9,822

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure I

Director Nomination Announcement: Microsoft

Microsoft proposes election of new board members

news.microsoft.com |

REDMOND, Wash. — Oct. 16, 2017 — Microsoft Corp. on Monday released its annual proxy statement and announced two nominations to its board of directors. The nominees are Penny S. Pritzker, founder and chairman of PSP Capital and former U.S. Secretary of Commerce, and Arne Sorenson, president and chief executive officer of Marriott International. Both are accomplished leaders and will bring significant global experience to Microsoft. They will be presented for election at the company's annual shareholders meeting on Nov. 29, 2017.

"Penny and Arne are both strong leaders with impressive accomplishments and contributions that span business and public service," said John Thompson, independent Microsoft board chairman. "They will serve as valuable additions to the board."

Pritzker, 58, is the founder and chairman of PSP Capital and its affiliate, Pritzker Realty Group. From June 2013 through January 2017, she served as U.S. Secretary of Commerce. She is an entrepreneur, civic leader and philanthropist and has nearly 30 years of experience as a business executive across numerous industries, building dozens of successful companies. Pritzker is a member of the board of trustees of the Carnegie Endowment for International Peace, a member of the Aspen Strategy Group and the Aspen Economic Strategy Group, and a co-chair of the Cyber Readiness Institute. She and her husband, Dr. Bryan Traubert, co-founded the Pritzker Traubert Foundation, a private philanthropic foundation that works to foster increased economic opportunity for Chicago's families.

Sorenson, 58, has served as president and chief executive officer of Marriott International since 2012 and was elected to Marriott's board of directors in 2011. In addition, he is the chairman of Marriott's Global Diversity and Inclusion Council and co-founded Marriott's Global Sustainability Council in 2007. In Sorenson's career at Marriott International, he has also served as chief operating officer, executive vice president, and chief financial officer and president of continental European lodging. Sorenson serves on the board of Brand USA. He is a member of the Luther College Board of Regents and is a member of the board of trustees for The Brookings Institution.

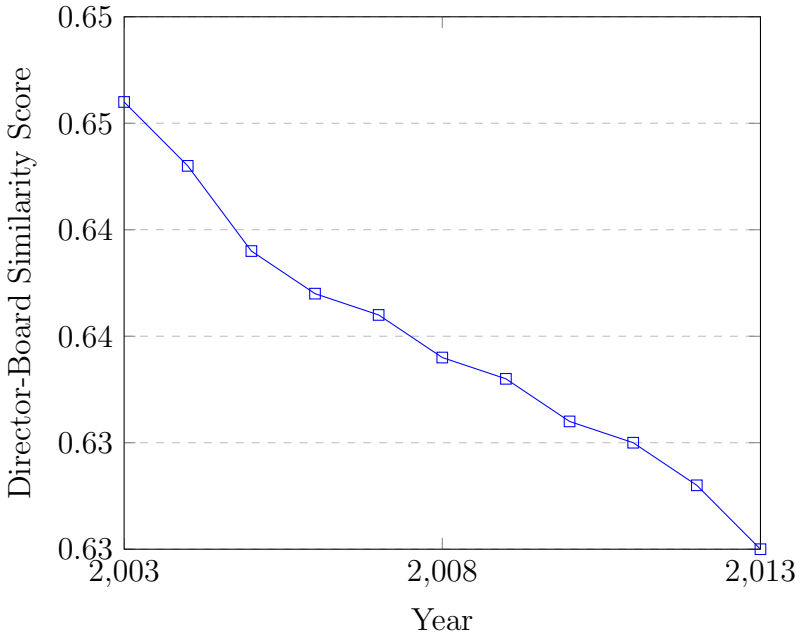
Other board members include John W. Thompson, Microsoft independent chairman; William H. Gates, Microsoft founder and technology advisor; Reid Hoffman, partner at Greylock Partners; Hugh Johnston, vice chairman and chief financial officer of PepsiCo; Teri L. List-Stoll, executive vice president and chief financial officer of Gap Inc.; Satya Nadella, chief executive officer of Microsoft; Charles H. Noski, former vice chairman of Bank of America Corp.; Dr. Helmut Panke, former chairman of the board of management at BMW AG; Sandra E. Peterson, group worldwide chair for Johnson & Johnson; Charles W. Scharf, chief executive officer of The Bank of New York Mellon Corp.; John W. Stanton, chairman of Trilogy Equity Partners; and Padmasree Warrior, CEO and chief development officer of NIO USA Inc.

Microsoft (Nasdaq "MSFT" @microsoft) is the leading platform and productivity company for the mobile-first, cloud-first world, and its mission is to empower every person and every organization on the planet to achieve more.

Figure II

Director-Board Similarity Score

This figure displays the annual average same-board director-director similarity score from 2003-2013. For each director on a board each year, a director-director similarity score is calculated by finding the similarity between their industry expertise vectors. The director-director similarity scores are averaged at the board level. The board-level average director-director similarity score is then averaged annually.



Annual Average Director Industry Expertise

This figure plots the annual average number of industry expertises for each director from 2003-2013. Industry expertise categorization is based on the Fama-French 12-Industry classification. The average number of industry expertises for all directors is 2.26 while the number is higher for incoming outside directors at 2.79.

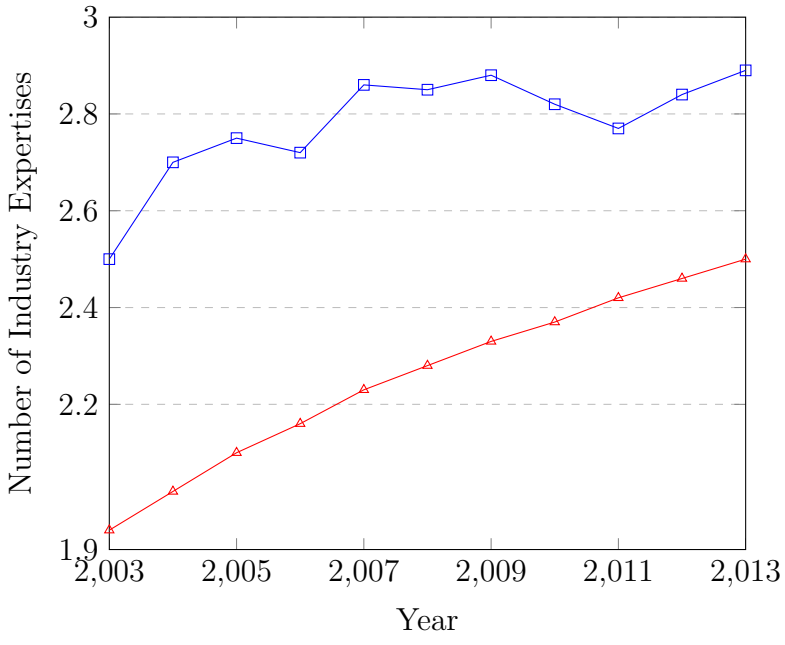
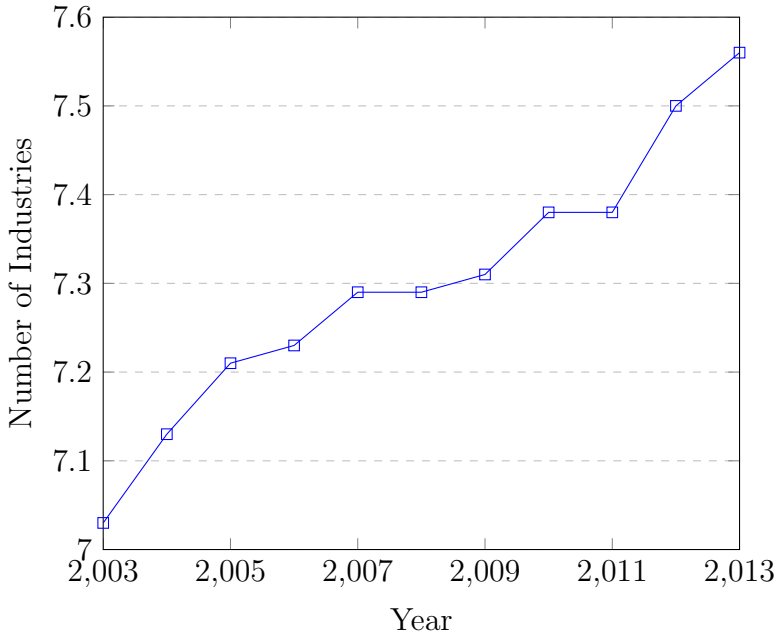


Figure III:
Total Number of Industries

The annual average number of industry expertises for each firm is plotted below. Industry expertise classifications are based on the Fama-French 12-Industry. Panel A. is the average number of industries each year. Panel B. is the average number of industries each year weighted by the firm's number of directors.



Normalized Industries: Total Industries/Number Directors