Directors, Outsiders and Efficiency: An Analysis of How Board Characteristics Influence Firm Productivity

Laarni Bulan[*] Paroma Sanyal[*] Zhipeng Yan[**]

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Abstract

This paper investigates the relationship between firm productivity (total factor productivity or TFP) and four different board characteristics, including board size, board independence, CEO board leadership and board ownership (shareholdings). We find that board independence is positively associated with productivity while CEO board leadership is negatively associated with productivity, unlike existing work that finds no relationship between these two board characteristics and firm financial performance. We also find that the consistent negative relationship between board size and financial performance does not apply to all firms when we use productivity as the measure of performance. Finally, we find that board ownership is related to productivity with an inverted U-shape, similar to prior work. Our sample consists of 1109 U.S. manufacturing firms between 1996 and 2005.

[*] lbulan@brandeis.edu and psanyal@brandeis.edu. Brandeis University, International Business School and Economics Department, 415 South Street, MS 021, Waltham, MA 02454.
[**] zyan@ADM.NJIT.EDU. New Jersey Institute of Technology, School of Management, University Heights, Newark, NJ 07102.
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Introduction

This paper investigates the relationship between board characteristics and the efficiency of corporations, as measured by total factor productivity. There is a sizable literature on the relationship between different board characteristics and firm financial performance, e.g. firm value (Tobin's q). The major characteristics of boards that have been extensively studied include board size, board independence[1], board ownership (shareholdings) and CEO board leadership[2]. On the other hand, very few studies have looked at the relationship between firm productivity and board characteristics. This line of inquiry is important for at least two reasons. First, academics, practitioners and policymakers alike are interested in the effectiveness of corporate governance mechanisms, such as the role played by a company's board of directors. This interest has been particularly fueled by the corporate scandals of this decade that began with Enron, WorldCom and Parmalat. Second, our focus on productivity sheds light on whether corporate boards have an effect on the "real-side" of firm performance. We argue that a corporate board's efforts directed at improving productivity is perhaps the most important mechanism through which a firm's long-term financial performance is positively impacted.

One of the primary responsibilities of the board of directors is to foster a company's long-term success. It is there to curb myopic CEO actions that may be detrimental to long-term firm fundamentals and to monitor overall company practices. The board is charged with mitigating agency problems faced by outside share-holders vis-à-vis company managers through formulating appropriate incentive compatible compensation schemes and to serve as an impartial overseer of the company. In its policy statement of corporate governance, TIAA-CREF states

[1] Board independence is usually measured by the number of outside (independent) directors scaled by the total number of directors.
[2] Board leadership is usually measured as whether the CEO is also the Chairman of Board (which is also referred to as combined leadership or CEO duality).

that "The board should also be responsible for the review and approval of the corporation's long-term strategy, the assurance of the corporation's financial integrity, and the development of equity and compensation policies that motivate management to achieve and sustain superior long-term performance"[3]. To contribute to our understanding of whether, in practice, boards fulfill their objective, we analyze the influence of board structure on firm productivity.

While prior studies that focus on firm financial performance investigate whether there are systematic relationships between board characteristics and firm value, it is also important to identify the underlying channel(s) through which a corporate board ultimately influences firm value. Productivity is one such channel since improvements in productivity are arguably more permanent (as opposed to transitory) and hence, would have lasting effects on firm value. We hypothesize that a value maximizing board of directors should exploit this channel of long-term value creation through productivity gains. Lichtenberg and Palia (1999), Schoar (2002) and Bulan, Sanyal and Yan (2009) have documented a positive relationship between productivity and firm financial performance as captured by Tobin's Q. Thus, improvements in productivity increase firm value.

We use a sample of 1109 manufacturing firms in the US during the period 1996-2005 to focus on the relation between board characteristics and firm productivity. By investigating this relationship we want to analyze which types of boards help in improving firm fundamentals that consequently increase shareholder value. We measure firm productivity as total factor productivity (TFP). Following Bulan, Sanyal and Yan (2009), we employ the Olley and Pakes (1996) methodology to obtain consistent estimates of TFP, with labor and capital as inputs to production. We then examine the relationship between TFP and board size, board independence,

[3] TIAA-CREF has very extensive research on boards of directors: please refer to http://www.tiaa-cref.org/pubs/html/governance_policy/board_directors.html.

board leadership and board shareholdings, controlling for basic determinants of productivity such as firm size, firm age, firm diversification and industry competition.

Our main findings are on the issue of board independence and CEO board leadership. Contrary to prior work that has not found a relationship between either board independence or CEO board leadership and firm financial performance, we find that productivity is increasing in the fraction of independent directors on the board while having a CEO who is also chairman of the board is negatively related to productivity. Furthermore, we find that the well documented negative relationship between board size and firm financial performance does not translate to productivity in general. Board size is negatively related to productivity only among firms that are smaller, more competitive, have low free cash flow and fewer growth opportunities. Finally, we find that the equity holdings of the board has an inverse U-shaped relationship with productivity. Over-all, our results support a systematic relationship between key board characteristics and total factor productivity. The challenge for future work is to tease out the drivers of these relationships via a board's monitoring and advisory roles in order to properly identify any causal effects board structure may have on firm performance.

This paper adds to a very thin empirical literature on firm productivity and board characteristics. This is especially meaningful at a time when the board of directors has to shoulder more responsibilities under a series of new legislations and rules. For instance, the Sarbanes-Oxley Act of 2002 has placed added emphasis on policies, procedures and methodologies by which directors fullfill their responsibilities[4]. Our results are particularly relevant in light of recent policies that call for more board independence and the separation of

[4] See the remarks of Harvey Pitt, former chairman of SEC on Nov 17, 2004, "Directors' Newest responsibility Under Sarbanes-Oxley: Ensuring the Existence of Effective Corporate Compliance and Ethics Programs."

CEO and Chairman roles. Whereas prior work finds no basis for such reform, our findings suggest the opposite.

The remainder of the paper proceeds as follows: Section I reviews the existing literature and discusses key implications of recent theoretical models. Section II describes the data and key variables. Section III reports our empirical results while Section IV concludes.

I. Literature Review and Theoretical Implications

There has been a lot of recent studies on corporate governance[5]. Prior empirical work consistently finds that board size is negatively related to financial performance (Yermack (1996), Eisenberg, Sundgren, and Wells (1998))[6] while board equity ownership has non-monotonic associations with financial performance (Morck, Shleifer and Vishny (1988), Cho (1998), Cui and Mak (2002)). In developed countries[7], the dominant evidence suggests no correlation between board independence and firm value, whether firm value is measured by Tobin's Q, or accounting performance measures, or long-term stock market performance (Hermalin and Weisbach (1991), Mehran(1995), Bhagat and Black (2000), Brick, Palia, and Wang(2005)). Lastly, board leadership is not significantly and systematically related to financial performance (Carapeto, Lasfer, and Machera (2005), Baliga, Moyer, and Rao (1996), Adams, Hermalin and Weisbach (2009)).

[5] Shleifer and Vishny (1997), Denis and McConnell (2003) and Gillan (2006) survey the broader literature of corporate governance.
[6] One significant exception is Coles, Daniel, and Naveen (2006), who find that firm value increases (decreases) in board size for complex (simple) firms and this relation is driven by the number of outside directors.
[7] Black, Jang, and Kim (2006) report the first evidence consistent with greater board independence causally predicting higher share prices in emerging markets in their study of Korean public firms.

Very few studies have systematically looked at the relationship between productivity and board characteristics[8]. Most papers employ only one or two board characteristic measures as one of many corporate governance variables. Rao and Lee-Sing (1995) find that in Canada large boards are associated with less R&D and poorer overall performance and productivity. In the United States, however, big boards seem to have little effect, either positive or negative. Köke (2001) finds that the size of the board is not significantly related to productivity growth. Using a five-year (1996-2000) panel data set of 333 Taiwanese listed electronics firms, Sheu and Yang (2005) find that neither the total insider ownership nor the board-to-insider holding ratio shows any influence on productivity.

The surge in empirical work paved the way for the emergence of theoretical models (Hermalin and Weisbach (1998), Raheja (2005), Harris and Raviv (2006), and Adams and Ferreira (2007)). These models assume the basic functions of the board are that of monitoring and advising management. The main focus is on board independence, which is traditionally measured by the fraction of external directors (outsiders) on the board. Insiders have private information about the firm. The relationship between insiders and outsiders and outsiders' ability to extract this private information is key to determining the optimal board structure. In general, one size does not fit all for firms and boards. One has to analyze the incentives for insiders to reveal their private information, the private benefits of insiders, the leverage of outsiders in determining CEO turnover and succession, the verification costs to outsiders of acquiring the private information, as well as the expertise and effort expended by outsiders.

[8]A few more studies investigate the relationship between firm productivity and managerial incentives (Palia and Lichtenberg (1999), Bulan, Sanyal and Yan (2009)), family ownership (Barth, Gulbrandsen, and Schøne (2005)), multinational ownership (Perez-Gonzales (2004)), and the existence of a dominant outside shareholder (Nickell, Nicolitsas and Dryden (1997) and Köke and Renneboog (2003)).

The implications of these models are rich and varied. For example, Raheja (2005) finds that firms with low outsider verification costs will have more independent directors and those where insider incentives are better aligned with shareholders will have smaller boards. Adams and Ferreira (2007) find that more independent boards (tougher monitors) are less effective in their advisory role because insiders are reluctant to reveal their private information to their *unfriendly* monitors. Similarly, Harris and Raviv (2006) find that insider controlled boards are optimal when private information is more valuable. Moreover, insider control creates incentives for outsiders to become better informed, which is beneficial to shareholders. Their model also predicts no relationship between firm performance and either board size or board independence since these are endogenously determined by external factors in their model. However, their model can generate the documented negative empirical correlation between board size and profitability from changes in these external factors. They also find that shocks to these external factors can induce a relationship between profits and the number of outsiders that is positive, negative, or there can be no correlation at all. Their model underscores the importance of addressing the issue of endogeneity for empirical work.

Although these models do not explicitly identify productivity as a measure of firm performance, we expect the same implications will apply to the relationship between productivity and board characteristics for two reasons: First, improvements in productivity have more permanent and lasting effects on firm financial performance. After-all, the real-side of firm performance should be more directly related to the long-run strategic goals of a firm. Second, Lichtenberg and Palia (1999), Schoar (2002) and Bulan, Sanyal and Yan (2009) have all documented a positive relationship between productivity and firm financial performance as

captured by Tobin's Q. Thus, productivity is an important channel through which governance mechanisms could ultimately affect financial performance.

II. Data

Our data is obtained from two main sources – IRRC (Investor Responsibility Research Center) and Compustat. We start with all firms in the IRRC Directors database between 1996 and 2005. The IRRC Directors database provides details on the structure and practices of the boards of directors at a large number of U.S. companies. The data is of annual frequency and covers directors of S&P 500, MidCap and SmallCap firms starting in 1996[9]. We obtain firm characteristics from Compustat. We focus exclusively on manufacturing firms, for which our productivity estimation is likely to be most reliable. Our sample thus comprises all 1109 of the manufacturing firms represented in both IRRC and Compustat with no missing observations for certain key variables[10]. Our primary sample consists of 6211 firm-year observations.

A. Measuring board characteristics

We use board size, board independence, board leadership and board shareholdings to capture important facets of board characteristics. Following prior research, we define board size as the total number of directors on the board, board independence as the ratio of the number of independent directors to board size, CEO board leadership (CEO duality) as whether the CEO also serves as the chairman of the board, and board shareholdings as the total number of shares held by the board scaled by total shares outstanding. All the measures are derived from the

[9] Including only S&P stocks may impose selection bias. In particular, S&P Small Caps 600 index has more stringent requirements for inclusion, unlike the larger Russell 2000, which also tracks small-cap stocks. Standard & Poor's adds new stocks to the index based not only on size, but also on financial viability, liquidity, adequate float size, and other trading requirements. Therefore, IRRC database may be comprised of higher-quality firms than the universe of stock market. Please refer to http://www.streetauthority.com/terms/index/sp600.asp

[10] These variables are productivity, lagged productivity, total assets, firm age, board size and the portion of outside directors.

IRRC database. We also follow IRRC's definitions of various board affiliations. Independent or outside directors are those who have no significant connection with the firm. Inside directors are current employees. Affiliated directors are those that have neither inside nor outside status.

Table 1, Panel A reports descriptive statistics for all sample firms of key board characteristics. The mean (median) board size is 9.01 (9). The average board size in our sample is smaller than the average size of 11-12 for large firms reported by Yermack (1996), and larger than that reported by Linck, Netter and Yang (2008), who report a mean (median) value of board size of 7.5(7). The former uses hand-collected data from 500 largest U.S. public firms listed on *Forbes* magazine between 1984 and 1991. The latter includes all firms in the Disclosure database between 1990 and 2004. Both studies include firms in all industries, except for financial and utility industries. The mean portion of outside, affiliated and inside directors on the board is 0.65, 0.14 and 0.21, respectively. It is consistent with those in the Bhagat and Black (2002), who, we believe, use virtually the same database as IRRC because both of them are compiled by Institutional Shareholder Services. The CEO is also the chairman of the board in 66% of their sample, almost equivalent to 65 % for our sample.

Panel B summarizes board characteristics over our ten year sample period. It suggests a general decline in board size except for small hikes in 2002 and 2003[11]. The proportion of outside directors has been increasing from 0.59 in 1996 to 0.73 in 2005, which implies that the proportion of either inside directors or affiliated directors has been gradually dropping over the past decade. There could be two possible reasons for the trend of decreasing board size with a higher portion of outside directors. First, there has been a long-standing view that smaller boards

[11] One plausible explanation for the temporary increase in average board size in 2002 and 2003 is that firms added independent directors in order to comply with the Sarbanes-Oxley Act of 2002, which requires that audit committees consist only of independent outside directors. In the years after, firms might be able to keep smaller boards while complying with the requirements in the meantime.

are more efficient than larger boards (Lipton and Lorsch (1992), Jensen (1993)). Shareholder advocates such as Institutional Shareholders Services, Inc. and the Council of Institutional Investors have called for smaller boards with greater outside representation among U.S. corporations (Boone, Eield, Karpoff and Raheja (2007)). Secondly, since the passage of the Sarbanes-Oxley Act of 2002, boards have been steadily paring down the number of their standing committees. "Between 2001 and 2003 almost every committee, except for the audit and compensation committees, has decreased in prevalence… Many of these second-tier committees were born in companies at a time when boards were significantly larger...as companies moved to reduce board size, the need for "ancillary" committees was reduced too"[12].

Panel C presents summary statistics for board characteristics across different firm size categories. We group firms into four quartiles based on their total real assets each year (in 2000 dollars). We define the first quartile "small", quartile two and three "medium", and quartile four "large". Board characteristics of large firms are very different from those of small and medium firms. In line with Linck, Netter and Yang (2008), we also find that large firms have larger and more independent boards. CEO and chairman of the Board posts are more often combined in large firms. Both outside directors and the board as a whole hold a greater proportion of shares in small firms. The differences between small and large firms are statistically different from zero for each board characteristic. Overall, the findings in this table support the notion that one size does not fit all for firms and their board structure.

B. Measuring Total Factor Productivity

Total factor productivity or TFP is the conventional measure of firm-level productivity. TFP is defined as the change in output that cannot be explained by a corresponding change in

[12] "Boards Consolidate Committee Responsibilities," *Board Alert, P2, Oct 2004*.

factor inputs. The two most commonly identified sources of productivity gains are changes in technology and unobserved efficiency increases. Early work has used ordinary least squares to estimate firm-level production functions. However, this method suffers from some serious flaws. The main problems are that of endogeneity of inputs, unobserved heterogeneity across firms and selection bias. Olley and Pakes (1996) developed a methodology that addresses these problems. We follow this procedure and obtain consistent estimates of TFP for each firm[13]. Since the underlying production function parameters may be different across industries, we estimate the production function separately for each industry group following the Fama-French 49 industry classification. TFP is then calculated as the residual between the predicted and actual output. Appendix A provides more details on the productivity estimation procedure.

To make the TFP estimates comparable across industries, we compute a productivity index (Pavcnik (2002), Aw, Chen and Roberts (2001)) as follows: We consider 1996 to be the base year for which we calculate the mean TFP estimate by industry group. We estimate industry mean TFP based on all the firms available in the Compustat data file, before we merge it with the IRRC directors data. We then subtract the1996 industry mean TFP from firm-level TFP to obtain the productivity index: $pindx_{it}=prodv\_est_{it} - prodv\_est_{j,1996}$, where j is the industry group of firm i and t denotes the current year. In the regression analysis that follows, we use this productivity index as the dependent variable. Table 2 provides descriptive statistics for this index. Figure 1a illustrates the time trend in the average productivity index from 1996 to 2005. There has been a steady increase in US firm-level productivity during this period with a temporary decline in year 2001 and year 2002 when the US economy was in recession.

[13] Another advantage of this methodology is that it yields productivity estimates that are robust to a variety of estimation issues. Its shortcoming is that these estimates can be quite sensitive to measurement error in investment (Biesebroeck (2004)). In this paper, investment is measured as capital expenditures (in property, plant and equipment). Since this is a flow variable that is reported by firms each year, we believe measurement problems are not that severe.

Productivity has been increasing at an accelerated pace since 2002. Figure 1b reports the trends in firm productivity index for small, medium, and large firms. It shows that, for our sample, larger firms have lower productivity[14].

C. Measuring Firm Characteristics

To evaluate the contribution of board characteristics to productivity, it is important to control for other important factors. We require the following additional factors in our analysis: firm size (total assets), firm age, number of business segments, industry concentration (Herfindahl index), free cash flow, tangible assets, capital expenditures, book leverage, volatility of monthly return, research and development, CEO shareholdings and CEO tenure. Further details on the measurement and construction of these variables are outlined in the appendix B. Table 2 reports summary statistics for these variables.

III. Regression Analysis

To determine the relationship between productivity and board characteristics, we need to address the endogeneity of board characteristics and firm performance (Hermalin and Weisbach (2003)). Firm performance is a result of the actions of previous and current directors, while the choice of subsequent directors is likely influenced by past and current firm performance. For example, a board can become more independent if large outside block shareholders can influence the nomination of more outside directors because they were not satisfied with the firm's performance. More often than not, a chairman-CEO can be fired and replaced by a non-Chairman CEO following poor performance.

[14] There is no consensus on whether firm size is positively or negatively associated with firm productivity. For instance, Grossmann (2007) predicts a positive relationship of firm size to productivity, while Dhawan (2001) finds that small firms are significantly more productive than their large counterparts.

For this study on firm productivity, we argue that endogeneity problem may not be as severe compared to studies that analyze firm financial performance. Contracting on productivity is practically impossible in the sense that a specific firm's TFP is not readily observable by shareholders, and thus is not a direct factor in determining board composition. But since productivity and financial performance are related, we still need to address this endogeneity issue. We do this by using generalized methods of moments (GMM) estimation. We report robust standard errors that corrects for heteroskedasticity and auto-correlation. The latter is because of the strong persistence in productivity over time. Serial auto-correlation of the productivity index is significant and large for our sample (around 0.9).

A. The basic regression model

To investigate whether board characteristics are systematically related to firm productivity, we estimate the following empirical model using GMM:

$$\text{Prod}_{it} = \beta_0 + \beta\, \text{Board Characteristics}_{it} + \gamma\, \textit{Controls}_{it} + \alpha_i + \delta_t + \mu_{it} \qquad (1)$$

The dependent variable is the productivity index previously described. *Board Characteristics* consists of log board size, board independence, CEO board leadership and board shareholdings. Numerous prior studies also document that there is a nonlinear relationship between firm performance and board shareholdings, though a variety of patterns of nonlinear relationships have been reported (Morck, Shleifer and Vishny (1988), Cho (1998), Cui and Mak (2002)). We therefore add the squared term of board shareholdings all our regressions. In addition to board characteristics, our regressions include the following control variables for productivity (for reasons outlined below): firm age, firm size (log of real assets), diversification (number of business segments) and industry concentration (log of Herfindahl index).

As shown in Figure 1b and in many other studies (Soderbom and Teal (2001), Grossmann (2007), and Dhawan (2001)), a firm's size has a significant impact on its productivity. In addition to firm size, it has been argued that firm productivity depends on firm age. Huergo and Jaumandreu (2004) find newborn firms tend to show higher rates of productivity growth which, as time goes by, converges on average to common (activity-specific) growth rates. Haltiwanger, Lulia, and Speltzer (1999), in a study of large Australian firms, find that older firms are on average less productive. Other studies have suggested that industry structure and competition can affect firm productivity. For example, Tang and Wang (2005) show that product market competition has a positive impact on the productivity of medium-sized and large-sized firms. Rogers (2004) finds that intense competition raises productivity growth in managerial workplaces, but not in non-managerial workplaces (i.e. where the principal owner also works).

Finally, there is a large literature about whether diversified firms are valued more or less in the capital markets than stand-alone businesses. Though there is no consensus on this issue[15], diversification has no doubt an important impact on firm productivity. Schoar (2002) finds that conglomerates are more productive than stand-alone firms at a given point in time. Dynamically, however, firms that diversify experience a net reduction in productivity. While the acquired plants increase productivity, incumbent plants suffer. Moreover, as Yermack (1996) argues, diversified firms are likely to have larger boards, because many boards grow in size when firms make acquisitions and because boards of conglomerates may seek outside expertise for a greater diversity of activities and industries.

[15] Lang and Stulz (1994) and Berger and Ofek (1995), among others, find that diversified firms are valued less. By using establishment level data, Villalonga (2004) shows that there is a diversification premium.

The GMM estimation procedure can only address the endogeneity problem if an appropriate set of instruments is used. Linck, Netter and Yang (2008) analyze the determinants of the key board characteristics that we use in our analysis. Thus, we use many of the factors that they identify to affect board structure as instruments in our empirical specification. Our instrument set includes: firm size (log real assets), firm age and age-squared, diversification (log number of segments), industry concentration (log Herfindahl index), leverage, stock return volatility, free cash flow, market-to-book ratio, research and development (R&D), CEO shareholdings, CEO tenure, and a dummy variable that equals one if the CEO was also chairman of the board in the previous year. Except for firm size and age, all firm characteristics are lagged one year to ensure that these variables are predetermined in the empirical model.

We summarize the use of these instruments as follows: Fama and Jensen (1983) and Lehn, Patro and Zhao (2004) argue that board characteristics are driven by the scope and complexity of the firm's operations which can be partly captured by firm size, firm age, the number of the firm's business segments and industry concentration. Large firms and more diversified firms are also likely to have larger boards. Free cash flow, leverage and R&D expenditure (discretionary spending) characterize the potential private benefits available to insiders (Boone et al.(2007)). Gillan, Hartzell, and Starks (2003) argue that directors will monitor less in noisy operating environments because of higher monitoring costs. Following Boone et al. (2007), we include a firm's market-to-book ratio and stock return volatility as proxies for the cost of monitoring insiders. In addition, Hermalin and Weisbach's (1998) theory implies that board composition reflects the outcome of a negotiation between the CEO and outside board members. Thus, we include CEO shareholdings, CEO tenure, and an indicator

variable if the CEO was also Chairman in the previous year to control for the relative bargaining power of the CEO relative to the firm's outside directors.

We report the Hansen J test for over-identifying restrictions to ensure the validity of our instruments. A p-value of less than 10 % would mean a rejection of the validity of the instruments at conventional levels of significance.

B. Results

Table 3 presents coefficient estimates for our basic model (column1). The Hansen J test shows that our specification is valid with a p-value of 83.7 %. We find no relationship between board size and productivity. This is consistent with the theoretical model of Harris and Raviv (2006)[16]. However, we do find a positive relationship between board independence (fraction of independent directors) and productivity while CEO board leadership has a negative relationship with productivity. Prior work has not found a relationship between either board independence or CEO board leadership and firm financial performance. Board ownership has an inverse-U relationship with productivity[17]. For the latter, productivity is first increasing and then decreasing in the proportion of shares held by the board of directors. The over-all relationship between firm productivity and board shareholdings in our sample is positive when the holdings are less than 39%, and becomes negative when the holdings are over 39%. Since the mean (median) value of board shareholdings is 9.26% (3.5%), for majority of firms in our sample, board shareholdings have a positive effect on firm productivity. Among the control variables, only the number of business segments is significantly related to productivity.

[16] Koke (2001) finds that the size of the board is not significantly related to productivity growth.
[17] Sheu and Yang(2005) find that neither total insider ownership nor the board-to-insider holding ratio shows any influence on productivity

For comparison to previous work, in column (2) we estimate a regression of Tobin's Q on the same board characteristics. In this model, we use the control variables and instruments identified by Himmelberg, Hubbard and Palia (1999). First of all, except for board independence, we observe the same relationships with Tobin's Q and board characteristics that we observe with firm productivity. However, the Hansen J test rejects the validity of the instruments with a p-value of 4.2 %. This further supports our choice to focus on productivity, as opposed to firm financial performance, as we expect the endogeneity problem to be less severe with the former compared to the latter.

C. Sample Splits

The theoretical models predict that the optimal board structure will depend primarily on certain key firm characteristics. For example, Raheja (2005) argues that firms for which verification of projects by outsiders is easy and inexpensive, (such as a supermarket chain) will have a higher proportion of independent directors or that firms in competitive industries will have smaller boards because incentives between managers and shareholders are better aligned. Along these lines, we split our sample according to various firm characteristics that could affect the factors that determine a board's structure. In doing so, we identify some important mechanisms through which boards may potentially affect firm performance.

In Table 4 we divide our sample according to high or low cohorts of firm size (real assets)[18], number of business segments and industry concentration (HHI). Larger firms are more established and mature. Firms with more business segments are more complex and will have costly verification of outside projects and more valuable insider information. Firms in industries with lower concentration are more competitive and will likely have more aligned interests of

[18] We also perform the split according to firm age and find similar results to those of firm size.

managers and shareholders. Overall, the signs of the coefficients on board characteristics (where significant) are similar to results from Table 2.

One main difference from the basic regression result is that among smaller firms and those in more competitive industries, board size is significantly negatively related to productivity. This suggests that smaller boards are more effective among smaller firms and for firms facing greater competitive pressures. This seems plausible if we believe that the agency conflict between managers and shareholders is less severe among these cohorts of firms. Smaller boards also mean lower coordination costs which could be preferable among small and competitive firms.

Controlling for board size, the positive relationship between board independence and productivity is significant among firms that are smaller, less diversified (fewer business segments) or more competitive. Thus, contrary to most existing work, outside directors still play an important role in influencing firm performance, perhaps not so much as monitors but as advisors to top management. For example, firms with fewer business segments are less complicated, would require less costly project verification and insider information would be relatively less valuable. Among more competitive firms, incentives between shareholders and managers are more aligned, and hence there would be less need for external monitors. In these cases, we find greater board independence is more effective in terms of positively impacting productivity which suggests the advisory role of outside directors dominates.

The significant negative coefficient on the CEO-Chairman dummy variable (CEO board leadership) is generally consistent across all sub-samples, with the exception of firms that are more diversified where it is insignificant. Thus, while CEO board leadership has not been systematically linked to the financial performance of a firm, we find that it is negatively related

to the real side of firm performance. Lastly, the inverse-U relationship between board shareholdings and productivity appears to be driven by less diversified and more competitive firms. Overall, we find significant relationships between the four board characteristics and firm productivity among small, less diversified and competitive firms.

We perform another set of sample splits in Table 5, where we divide the sample according to high or low cohorts of free cash flow, R&D intensity (R&D/property, plant and equipment) and market-to-book ratio. We expect that the agency problem between managers and shareholder would be more severe when a firm has high free cash flow, since there is more scope for extracting private benefits. Similarly, high R&D, as a measure of discretionary spending, also reflects this agency conflict to a certain degree. Moreover, high R&D also represents riskier investments where project verification would be more difficult and insider information more valuable. Firms with high growth opportunities (high market-to-book ratios) would typically consist of young, high growth firms where verification of projects could also be more costly and insider information more valuable.

The table shows the signs of the coefficients on board characteristics (where significant) are similar to those from the basic model, although the Hansen J test rejects the model specification for the high free cash flow (coulmn1) and high market-to-book (column 5) sub-samples. Hence, we will refrain from making inferences regarding these two cohorts of firms. On the other hand, the negative coefficient on board size is significant among low free cash flow (column 2) and low market-to-book firms (column 6), consistent with the findings in Table 4 that smaller boards are effective when agency problems are less severe.

Across the four cohorts where the model is not mis-specified, board independence is positive and significant while CEO duality is negative and (mostly) significant, consistent with

the basic regression results. Moreover, we find that these effects are larger in absolute value or more significant among high R&D firms compared to low R&D firms. This suggests that for R&D intensive firms (riskier firms) where project verification is costly, insider information is more valuable and agency conflicts could be more severe, board independence and the separation of CEO and Chairman, respectively, are positively and negatively related to productivity. These results seem counter to some of the predictions of the theoretical models.

Despite the numerous forces affecting the incentives of managers, directors and ultimately board structure, the signs, and in many cases the significance, of the coefficients in Tables 4 and 5 are consistent across all sample splits,. These empirical regularities, and the fact that for the most part, the validity of our model specification cannot be rejected, leads us to conclude that there are systematic relationships between these board characteristics and the real side of firm performance. The challenge for future work is to tease out the drivers of these relationships via a board's monitoring and advisory roles in order to properly identify any causal effects board structure may have on firm performance.

IV. Conclusions

There has been much interest in the effect of different board characteristics on a firm's financial performance. This paper contributes to our knowledge on the relationship between firm productivity – the real side of firm performance -- and board characteristics using a sample of 1017 firms from 1996 to 2005. We follow Olley and Pakes (1996) to obtain consistent estimates of TFP and then proceed to investigate the effect of board characteristics on TFP.

We find a positive association between board independence and productivity and a negative association between board leadership and productivity. We also find that board size is

negatively related to productivity only among certain groups of firms. Lastly, we find that board shareholdings are significantly associated with productivity with an inverted U shape. Our results are particularly relevant in light of recent policies that call for more board independence and the separation of CEO and Chairman roles. Whereas prior work finds no basis for such reform, our findings suggest the opposite.

Appendix A: Estimating Total Factor Productivity

Consider that firms have idiosyncratic efficiencies but face the same market structure and factor prices. Firms produce output (y) using a fixed factor, capital (k), and a variable input such as labor (l), as given by the equation below.

$$y_{it} = \alpha_0 + \beta_1 l_{it} + \beta_2 k_{it} + \omega_{it} + \varepsilon_{it} \qquad (2)$$

In this equation, ω_{it} is the efficiency parameter that is unobserved by the econometrician but known by the firm when making investment and staffing decisions. ε_{it} is the idiosyncratic error term. Endogeneity arises from the fact that, 1) the capital stock is correlated with productivity through past productivity and selection bias, and 2) firms with a larger capital stock may continue to produce even at low productivity levels. Thus the coefficient on capital may be biased downward. The selection bias exists because OLS does not control for firm exit, which may occur due to a negative productivity shock.

Olley and Pakes (1996) have developed a methodology for the consistent estimation of a firm-level production function. They assume that efficiency is a function of investment and capital and that there exists a monotonic relationship between investment and unobserved firm-level productivity. They then use this to correct for the simultaneity issue. They correct for the selection bias by calculating the survival probability of a firm. The primary condition that is needed to implement this methodology is that firms have positive investment. For our sample of firms, this condition is easily satisfied.

The estimation sample consists of US manufacturing firms from 1996 to 2005 that are included in Compustat and IRRC. We classify these manufacturing firms into industry groups

following the Fama-French 49 industry classification[19]. The largest industry group in our sample is 'Chips' and the smallest group is 'Soda'. We calculate the productivity estimates separately for each industry group since the underlying production function parameters may be different across these groups.

[19] We only include those industries that have at least 75 observations during our sample period to obtain reliable productivity estimates. The industry grouping is from Ken French's website.

Appendix B: Variable Construction

All variables used as covariates are winsorized at the 1 % tails. (Compustat data item in parenthesis)

1. Variables used in the Productivity Estimation

Output = Sales (data12) deflated by the producer price index (PPI) at the four-digit SIC level[20]

Capital Stock = We use the perpetual inventory method to calculate the replacement value of the capital stock. The inputs are gross property plant and equipment (data7), depreciation (data14), capital expenditures (data128) and the price index for non-residential private fixed investment[21]. See Salinger and Summers (1983) for more details.

Labor = Employees (data29)

Investment = Capital expenditures (data128) deflated by the price index for non-residential private fixed investment

2. Board Characteristics Measures

Board Size = Number of directors on board as of the annual meeting date during each year.

Inside director = Number of directors who are currently employees of the firm

Affiliated or linked director = Number of directors who provide (or whose employer provides) professional services to the company or is major customer. It also includes directors who were former employees; recipients of charitable funds; interlocks; and family members of a director or executive)

Independent director (or, outside director) = Number of independent (no significant connection with the firm)

Board independence = fraction of independent/outside directors on board

CEO_Chairman = 1 if CEO is also chairman of the board, a dummy variable

Board shareholdings = total number of shares of the firm held by all the directors/total shares outstanding.

Outside directors shareholdings = total number of shares of the firm held by the outside directors/total shares outstanding.

[20] The PPI is obtained from the Bureau of Labor and Statistics website.
[21] This price index is obtained from the Bureau of Economic Analysis website.

All the measures are derived from IRRC directors database. One caveat is in place for board shareholdings. IRRC has an item called 'stkholding', which indicates the percent of shares owned by each director. However, there are only 10.70% of total observations with non-missing and non-zero values of 'stkholding'. Therefore, we decide, instead, to define shareholdings as the ratio of shares held by the director(item 'sharesheld') over the total common shares outstanding from proxy (item 'votecref'). If item 'votecref' is missing, we use shares outstanding at the end of the month when the annual meeting convenes from CRSP monthly database (item 'shrout'). Under this definition, 77.73% of total observations have positive stockholdings.

We measure stock return volatility as the standard deviation of monthly returns for the previous 60 months, reported by ExecuComp. If this is missing, it is calculated using CRSP data.[22] See Core and Guay (2002) for more details.

3. Variables used as Determinants of Productivity

Firm Size = Log(Total Assets) (data6) [23]

Firm age = current year – incorporation year[24] where available; if the incorporation year is unavailable, we use the earliest year on CRSP that a firm has a positive stock price or the earliest year in Compustat that a firm has non-missing data for total assets

Number of Business Segments = the number of business segments the firm has. It is calculated using Compustat Segment Data File.

Industry Concentration Index = Herfindahl Index based on Compustat data. This is given by: $\Sigma\alpha_i^2$ where α_i is the output (sales) share of each firm in the industry in that particular year and is summed over all firms in the industry. This is an industry concentration measure and the closer to zero this measure is, the more competitive the industry.

4. Additional Variables

Tobin's q = (data199*data25+ 10*data19 + data181)/data6, following Himmelberg, Hubbard and Palia (1999)

Tangible Assets, K/S = net property, plant and equipment / sales (data8/data12)

Investment, I/K = capital expenditures / net property, plant and equipment (data128/data8)

Free Cash Flow, FCF = (data18 + data14 - data128)/data6, following Boone, et,al (2007)

[22] Our findings are unchanged if we use the standard deviation of daily returns for the previous 252 trading days.
[23] The use of total sales as a measure of firm size leaves our results mostly unchanged and qualitatively similar. We remain cautious however, with this alternative specification because total sales is the measure of output in the productivity estimation.
[24] We are grateful to John Ritter for the use of his data on incorporation dates.

Volatility = the standard deviation of the previous 60 months stock returns, reported by ExecuComp, and if missing, is calculated from CRSP

Book leverage = (data6-book equity)/data6 where book equity = (data6 – data181 + data35 – data10)

R&D/K = R&D expenditures / net property, plant and equipment (data46/data8)

CEO *Holdings* = number of shares of the firm held by the CEO/total shares outstanding
It is derived from derived from IRRC directors database. If this is missing, it is calculated using ExecuComp**.**

CEO Tenure = current year – year the executive became CEO, as reported in ExecuComp

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Figure 1a: Productivity Index (the whole sample)

Total factor productivity is the estimated residual from a Cobb-Douglas production function with labor and capital as factor inputs. Estimation of the productivity index is described in Appendix A.

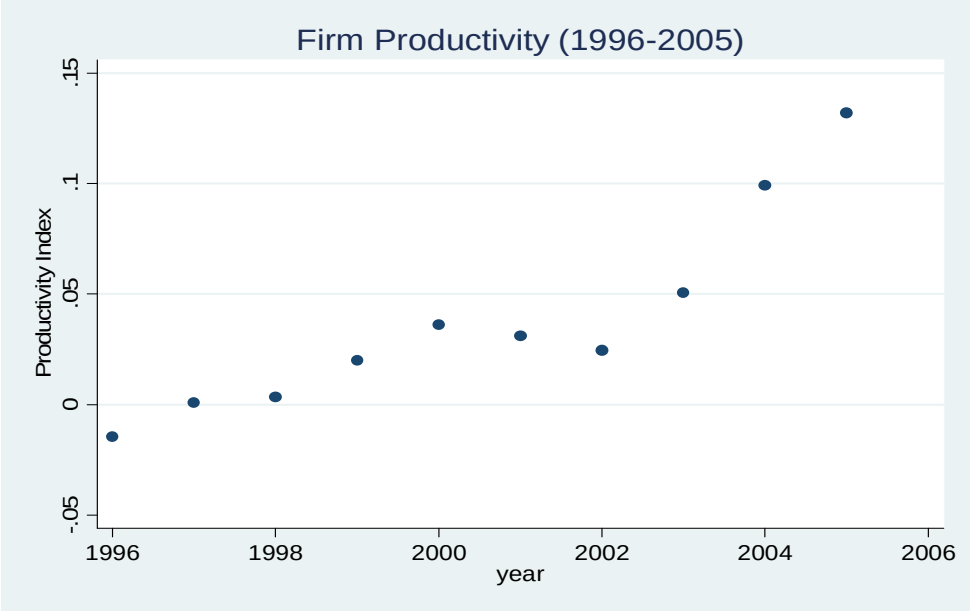

Figure 1b: Productivity Index (size groups)

We form the size groups by ranking the firms into quartiles based on their real asset values (in 2000 dollars). We label the first quartile firms "small", quartiles two and three "medium", and quartile four "large".

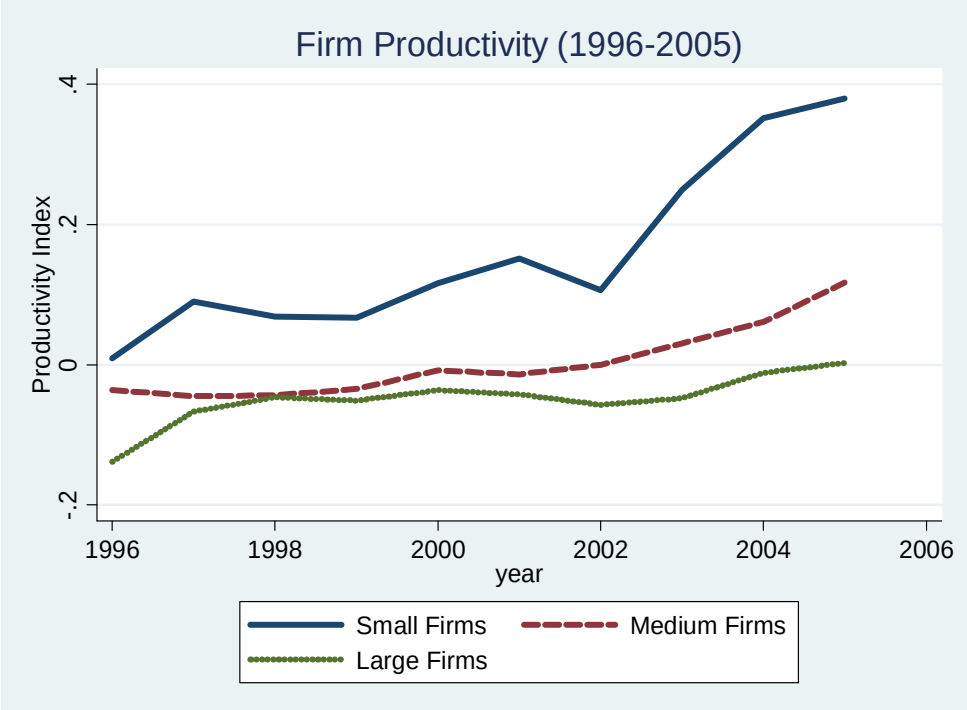

Table 1: Board of Directors Characteristics

The sample consists of 6211 annual observations for 1109 firms between 1996 and 2005. Firms are included if they have non-missing observations for the productivity index, total assets, board size and the portion of outside directors. Panel A presents the mean, median, minimum, maximum and standard deviation for each variable. Panel B reports the mean value in each year for each variable. Panel C presents mean and median for each variable in three size groups. We form the size groups by ranking the firms into quartiles based on their real asset values (in 2000 dollars). We label the first quartile firms "small", quartiles two and three "medium", and quartile four "large". Please refer to Appendix B for the definition of each variable.

Panel A – Board Characteristics

Variable	Mean	Median	Std.	Min	Max	N
Entire Board	9.01	9	2.55	1	22	6211
Outside directors	5.89	6	2.38	1	15	6198
Affiliated directors	1.30	1	1.37	0	9	6136
Inside directors	1.85	2	1.08	1	10	6136
% Outside directors	0.65	0.67	0.18	0	1	6211
% Affiliated directors	0.14	0.11	0.14	0	0.80	6136
% inside directors	0.21	0.18	0.11	0.06	0.80	6136
CEO_chairman (dummy variable)	0.65	1	0.48	0	1	6211
Board shareholdings (%)	9.26	3.50	13.99	0	99.31	5546
Outside directors shareholdings (%)	1.37	0.26	4.54	0	94.26	5604

Panel B – Board Characteristics (mean values) by year

Variable	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Entire Board	9.71	9.34	9.24	9.23	8.97	8.80	8.91	9.00	8.53	7.88
Outside directors	5.89	5.74	5.71	5.80	5.79	5.78	6.07	6.32	6.15	5.77
Affiliated directors	1.71	1.51	1.49	1.46	1.32	1.25	1.16	1.08	0.93	0.81
Inside directors	2.16	2.10	2.05	1.96	1.88	1.79	1.69	1.59	1.53	1.41
% Outside directors	0.59	0.61	0.61	0.62	0.64	0.65	0.68	0.70	0.72	0.73
% Affiliated directors	0.18	0.16	0.16	0.16	0.15	0.14	0.13	0.12	0.11	0.10
% inside directors	0.23	0.23	0.23	0.22	0.22	0.21	0.20	0.18	0.19	0.19
CEO_chairman (dummy variable)	0.66	0.69	0.69	0.64	0.64	0.64	0.68	0.67	0.63	0.59
Board shareholdings (%)	N/A	9.89	9.41	10.19	10.01	10.11	9.08	8.70	7.77	6.91
Outside directors shareholdings (%)	N/A	1.22	1.16	1.47	1.43	1.62	1.48	1.42	1.31	1.12

Table 1: Board of Directors Characteristics (cont'd)

Panel C – Board Characteristics (mean values) by size (asset values)

Variable	Small		Medium		Large	
	Mean [a]	Median	Mean	Median	Mean	Median
Entire Board	7.46***	7	8.82	9	10.93	11
Outside directors	4.59***	4	5.65	6	7.67	8
Affiliated directors	1.15***	1	1.33	1	1.40	1
Inside directors	1.78***	2	1.86	2	1.88	2
% Outside directors	0.61***	0.63	0.64	0.67	0.70	0.73
% Affiliated directors	0.15*	0.13	0.15	0.13	0.13	0.10
% inside directors	0.24***	0.20	0.21	0.18	0.17	0.15
CEO_chairman (dummy variable)	0.55***	1	0.65	1	0.77	1
Board shareholdings (%)	13.11***	7.39	9.29	3.73	5.37	1.06
Outside directors shareholdings (%)	1.99***	0.67	1.18	0.29	1.13	0.07

Note: The Wilcoxon rank sum test is performed between small firms and large firms. * significant at 10%; ** significant at 5%; *** significant at 1%.

Table 2: Summary Statistics

The sample consists of 6211 annual observations for 1109 firms between 1996 and 2005. Firms are included if they have non-missing observations for the productivity index, total assets, board size and the portion of outside directors. Total assets and total sales are reported in 2000 dollars. Please refer to Appendix B for the definition of each variable.

Variable	Mean	Median	Std. Dev.	Min.	Max.	Obs.
Productivity Index	0.02	0.02	0.48	-2.42	2.31	6211
Total Assets($M)	4589.54	1100.53	17463.60	17.01	419744.10	6211
Total Sales($M)	4193.02	1090.58	13317.77	2.13	289392.10	6211
Firm Age	41.01	46.00	21.59	3.00	147.00	6200
Industry Concentration Index	636.68	485.34	571.95	126.36	4868.60	6211
Market to book ratio	2.80	2.21	20.39	-983.48	655.71	6194
Tobin's Q	2.13	1.62	1.72	0.49	39.12	6195
Return on Assets	0.13	0.14	0.11	-1.01	0.64	6210
Tangible Assets, K/S (Net Property, Plant and Equipment/Total Sales)	0.31	0.23	0.29	0.01	7.49	6211
Investment, I/K (capital expenditures/Total sales)	0.22	0.19	0.14	0.00	2.06	6211
Book Leverage	0.50	0.50	0.23	0.01	2.34	6197
Free Cash Flow	0.02	0.04	0.16	-5.14	0.41	6211
Segment number	2.81	2	2.01	1	17	6211
Volatility of monthly return	0.44	0.38	0.21	0.12	3.28	6194
RD/K (R&D/Net Property, Plant and Equipment)	0.37	0.08	1.20	0	54.67	4686
CEO shareholdings (%)	3.99	1.20	8.77	0	93.10	5813
CEO tenure (years)	5.32	2.75	7.24	0	54.78	6211

Table 3: Board Characteristics and Firm Performance

GMM regression coefficient estimates of the association between firm performance and board characteristics, which include the number of directors sitting on firm boards (board size), the ratio of independent directors to total, CEO duality and total shares held by the boards. The full sample consists of 6211 annual observations for 1109 firms between 1996 and 2005. Firms are included if they have non-missing observations for the productivity index, total assets, board size and the portion of outside directors. HHI is the industry Herfindahl Index. Column (2) also includes dummy variables to control for missing values of R&D and Advertising. Robust standard errors are reported in parenthesis adjusted for heteroskedasticity. Moreover, standard errors in column (1) are adjusted for autocorrelation and in column (2) are clustered by firm. * significant at 10%; ** significant at 5%; *** significant at 1%. All equations contain year fixed effects.

	Dependent Variable	
	Productivity Index	Tobin's Q
	(1)	(2)
Board Characteristics		
Ln (Board Size)	-2.037	-3.351
	(1.548)	(2.412)
Fraction of Independent Directors	6.589**	8.401
	(3.266)	(9.176)
Dummy for CEO as Chairman	-0.427***	-1.107**
	(0.145)	(0.533)
Board Holdings (%)	0.231***	0.734**
	(0.077)	(0.326)
Board Holdings Squared	-0.004***	-0.018***
	(0.002)	(0.007)
Firm Characteristics		
Age	0.002	
	(0.003)	
Ln(Asset)	0.289	0.617*
	(0.179)	(0.363)
Number of Segments, Lag 1 Yr.	-0.057**	
	(0.024)	
Ln(HHI), Lag 1 Yr.	0.105	0.560
	(0.101)	(0.406)
Tangible Assets, K/S		-0.203
		(0.352)
Investment, I/K		0.303
		(1.003)
Book Leverage		0.674
		(1.360)
Volatility		-2.096
		(1.379)
R&D/K		0.018
		(0.087)
Advertising/K		0.584
		(0.545)
Relevant Statistics		
Observations	4958	4923
F-Statistic	2.802	0.353
Hansen J Statistic (p-value)	0.837	0.042

Table 4: Board Characteristics and Firm Productivity
Sample Splits I

GMM regression coefficient estimates of the association between firm productivity and board characteristics, which include the number of directors sitting on firm boards (board size), the ratio of independent directors to total, CEO duality and total shares held by the boards. The full sample consists of 6211 annual observations for 1109 firms between 1996 and 2005. Firms are included if they have non-missing observations for the productivity index, total assets, board size and the portion of outside directors. The sample is split according to the overall median values of real assets, number of business segments and the HHI (Herfindahl Index). Robust standard errors are reported in parenthesis adjusted for heteroskedasticity and autocorrelation. *significant at 10%; ** significant at 5%; *** significant at 1%. All equations contain year fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)
	Real Assets		Number of Segments		HHI	
	High	Low	High	Low	High	Low
Board Characteristics						
Ln (Board Size)	-0.198	-2.975***	1.363	-0.761	1.420	-4.178***
	(0.951)	(1.044)	(1.565)	(0.770)	(1.841)	(1.302)
Fraction of Independent Directors	1.087	7.830***	-3.608	4.602***	2.041	7.888***
	(2.133)	(2.921)	(3.140)	(1.748)	(1.264)	(2.867)
Dummy for CEO as Chairman	-0.246**	-0.273**	0.174	-0.342***	-0.298**	-0.603***
	(0.123)	(0.114)	(0.194)	(0.101)	(0.122)	(0.216)
Board Holdings (%)	0.097	0.119**	-0.062	0.177***	0.127	0.189***
	(0.065)	(0.049)	(0.102)	(0.055)	(0.082)	(0.070)
Board Holdings Squared	-0.002**	-0.001	0.000	-0.004***	-0.003	-0.003**
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)
Firm Characteristics						
Age	0.000	0.002	-0.002	0.001	-0.006	0.006*
	(0.002)	(0.003)	(0.002)	(0.002)	(0.004)	(0.003)
Ln(Asset)	-0.007	0.319**	-0.216	0.112	-0.121	0.517***
	(0.126)	(0.141)	(0.203)	(0.088)	(0.139)	(0.169)
Number of Segments, Lag 1 Yr.	-0.038***	-0.019	0.028*	-0.037	-0.054	-0.027
	(0.014)	(0.023)	(0.015)	(0.108)	(0.036)	(0.020)
Ln(HHI), Lag 1 Yr.	0.025	0.077	-0.037	0.192	0.160	0.301
	(0.059)	(0.102)	(0.045)	(0.125)	(0.153)	(0.218)
Relevant Statistics						
Observations	2545	2413	2512	2446	2330	2628
F-Statistic	3.033	2.246	0.880	3.526	2.196	1.583
Hansen J Statistic (p-value)	0.208	0.328	0.330	0.560	0.192	0.402

Table 5: Board Characteristics and Firm Productivity
Sample Splits II

GMM regression coefficient estimates of the association between firm productivity and board characteristics, which include the number of directors sitting on firm boards (board size), the ratio of independent directors to total, CEO duality and total shares held by the boards. The full sample consists of 6211 annual observations for 1109 firms between 1996 and 2005. Firms are included if they have non-missing observations for the productivity index, total assets, board size and the portion of outside directors. The sample is split according to the overall median values of free cash flow, R&D expenditure and market-to-book ratio. HHI is the industry Herfindahl Index. Robust standard errors are reported in parenthesis adjusted for heteroskedasticity and autocorrelation. * significant at 10%; ** significant at 5%; *** significant at 1%. All equations contain year fixed effects.

	(1)	(2)	(3)	(4)	(5)	(6)
	Free Cash Flow		R&D		Market-to-Book Ratio	
	High	Low	High	Low	High	Low
Board Characteristics						
Ln (Board Size)	-0.979***	-4.617**	-1.607	0.104	-1.691***	-2.264**
	(0.339)	(2.317)	(1.504)	(0.453)	(0.464)	(0.890)
Fraction of Independent Directors	0.920	8.302*	7.324**	2.125**	4.374**	3.382***
	(1.299)	(4.527)	(3.415)	(0.834)	(1.958)	(1.285)
Dummy for CEO as Chairman	-0.154***	-0.555*	-0.798***	-0.086	-0.285***	-0.235**
	(0.055)	(0.312)	(0.300)	(0.056)	(0.085)	(0.108)
Board Holdings (%)	0.027	0.294*	0.240	0.078***	0.095*	0.118**
	(0.023)	(0.164)	(0.159)	(0.025)	(0.051)	(0.047)
Board Holdings Squared	-0.001	-0.004*	-0.004	-0.001***	-0.001	-0.002**
	(0.000)	(0.002)	(0.004)	(0.000)	(0.001)	(0.001)
Firm Characteristics						
Age	-0.002**	0.011	-0.004	0.001	-0.002*	0.004*
	(0.001)	(0.007)	(0.004)	(0.001)	(0.001)	(0.002)
Ln(Asset)	0.061	0.567*	0.271**	0.031	0.193***	0.226**
	(0.042)	(0.309)	(0.136)	(0.053)	(0.067)	(0.104)
Number of Segments, Lag 1 Yr.	-0.015**	-0.052	-0.036	-0.029**	-0.011	-0.036*
	(0.007)	(0.043)	(0.030)	(0.012)	(0.012)	(0.019)
Ln(HHI), Lag 1 Yr.	-0.013	-0.095	-0.100	0.047	0.028	-0.020
	(0.029)	(0.162)	(0.093)	(0.068)	(0.054)	(0.088)
Relevant Statistics						
Observations	2520	2438	2444	2514	2524	2433
F-Statistic	10.050	0.892	2.913	1.674	4.753	2.946
Hansen J Statistic (p-value)	0.000	0.940	0.461	0.538	0.000	0.344