Engineer CEOs and Firm Performance in BIST Manufacturing Firms

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ABSTRACT

We study the relation between the educational background of chief executive officers (CEOs) and firm performance for 122 manufacturing firms traded on Borsa Istanbul (BIST) between 2009-2015. We analyze two different measures of performance, namely operating performance and market-based performance. We find that firms that have CEOs with an engineering background experience higher operating performance measured by return on assets (ROA) than firms that have CEOs with other educational background. Moreover, firms with engineer CEOs also experience better market-based performance measured by Tobin's Q. The positive association between having CEOs with an engineering background and firm performance that we document is robust to the inclusion of several firm-level control variables in our multivariate analysis. We also find that this positive relation is more pronounced for public manufacturing firms of smaller size.

Keywords: *Chief Executive Officer (CEO), Educational Background, Engineering, Firm Performance, Borsa Istanbul.*

Jel Classification*: G30, G34.*

BIST İmalat Firmalarındaki Mühendis CEO'lar ve Firma Performansı

ÖZET

Bu çalışmada Borsa İstanbul'da 2009-2015 arası işlem gören 122 imalat firmasındaki icra kurulu başkanının (CEO) öğrenim geçmişi ile firma performansı arasındaki ilişki incelenmiştir. Faaliyet performansı ve piyasa bazlı performans olmak üzere iki farklı performans ölçüsü analiz edilmiştir. Bulgularımıza göre icra kurulu başkanı mühendislik kökenli olan firmalar, icra kurulu başkanı diğer öğrenim geçmişlerinden olan firmalara kıyasla varlıkların getirisi bakımından daha yüksek faaliyet performansı göstermektedir. Ayrıca, icra kurulu başkanı mühendis olan firmalar Tobin's Q oranı bakımından da daha iyi piyasa bazlı performans göstermektedir. Mühendislik kökenli icra kurulu başkanı sahibi olma ile firma performansı arasında göstermiş olduğumuz pozitif ilişki, firma düzeyindeki çeşitli kontrol değişkenlerinin çok değişkenli analizimize dahil edilmesinden etkilenmemektedir. Ayrıca bu pozitif ilişki daha küçük boyutlu halka açık imalat firmaları için daha belirgindir.

Anahtar Kelimeler: *İcra Kurulu Başkanı (CEO), Öğrenim Geçmişi, Mühendislik, Firma Performansı, Borsa İstanbul.*

JEL Sınıflandırması: *G30, G34.*

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1. INTRODUCTION

The chief executive officer (CEO) is the highest-ranking executive in a company, who makes major corporate decisions and oversees all the company's various operations. As a result, the CEO is a key player in the company who is responsible for corporate performance and ultimately for the success or failure of a corporation.

Because CEOs come from different backgrounds and therefore have diverse skill sets, their influence on company performance might be different depending on their own characteristics and also on company characteristics. In this paper, we study one observable attribute of CEOs, namely their educational background, and analyze its relation to firm performance.

Specifically, we focus on CEOs with an educational background in engineering. Engineers tend to have an advantage when it comes to science and technology. Moreover, engineers possess strong analytical thinking and problem solving skills. Therefore, in our study, we distinguish between CEOs who hold an engineering degree and CEOs who hold a degree other than engineering, whom we denote as "engineer CEOs" and as "non-engineer CEOs", respectively. Moreover, since the technical skills and knowledge obtained in an engineering education will especially be useful in firms operating in the manufacturing sector, our study focuses on manufacturing firms. We argue that the potential ability of engineer CEOs to evaluate operations of their firms better suggests that engineer CEOs might be sought after in firms, especially manufacturing firms, to improve firm performance.[1]

Most evidence of the relation between the educational background of CEOs and firm performance relates to companies in developed countries, mainly the United States (US). Studies on various aspects of CEO education in US firms date back to 1970s. For example, while studying executive succession in US firms, Hall (1976) looks at the education level attained by the CEO and the major area of study of the CEO, where engineering, science, business and liberal arts are the areas considered. Even today, the education of the CEO and its effect on various firm decisions continue to be a topic of interest to researchers. For example, using data from a sample of listed firms in developed European countries, Kouaib and Jarboui (2016) examine the impact of CEO education on earnings management together with CEO age, CEO tenure and CEO overconfidence.

The characteristics of CEOs and their relation to firm-level characteristics and outcomes remain relatively unexplored for companies in developing countries, with most of the research in this context being conducted on Chinese companies. In a recent paper, Lu and Zhang (2015) examine the impact of CEO education on firm performance for publicly listed Chinese firms and find that CEO education is positively related to firm value. Our study aims

[1] In studies focusing on social skills of CEOs rather than technical skills, CEOs with a degree in social sciences form the focus of the study. For example, in a paper on the impact of CEOs on corporate social performance of US firms, Manner (2010) uses the degree of the CEO in humanities and social sciences as the main variable of interest.

to extend this literature by focusing on firms whose shares are traded on the emerging stock market of a developing country, namely Borsa Istanbul (BIST) in Turkey. In order to test whether there is a significant relation between the educational background of CEOs and firm performance for BIST companies, we conduct both univariate and multivariate analyses for the time period 2009-2015.

In our univariate analysis, we first create two subsamples of firms according to the education of their CEOs, where one subsample consists of firms with engineer CEOs and the other subsample consists of firms with non-engineer CEOs. The univariate analysis then enables us to find summary statistics such as the mean of firm financials, including firm performance measures, for these two groups of firms so that we can describe the characteristics of these two subsamples and subsequently compare them.

Our univariate comparison of firm financials between firms with engineer CEOs and firms with non-engineer CEOs shows that these two subsamples of firms are structurally similar with regard to their financials except their operating performance and market-based performance, which are higher for firms with engineer CEOs. This finding indicates that the presence of an engineer CEO might play the key role in explaining the observed differences in firm performance.

The multivariate analysis, on the other hand, enables us to test the relationship between the education of the CEO and firm performance measures in a setting where we can account for other firm financials that might be related to firm performance. Specifically, we employ OLS regressions with multiple explanatory variables to test whether there is a significant association between our main variable of interest, i.e. the CEO education, and firm performance after controlling for several firm financials. The coefficient estimate of the main variable of interest in OLS regressions will then indicate the expected change in firm performance measure with respect to a change in CEO education while holding all other firm financials constant.

In our multivariate analyses, we include several firm-level control variables that are found to have a significant effect on firm performance in existing literature, in addition to our main variable of interest which defines the major of the CEO. We find that the presence of an engineer CEO is significantly and positively associated with operating performance measured by return on assets as well as market-based performance measured by Tobin's Q. In terms of economic magnitudes, the presence of an engineer CEO is associated with an increase of 31% in return on assets from its mean level, and with an increase of 8% in Tobin's Q from its mean level. These findings imply that the specific human capital of engineer CEOs might help improve both operating and market-based performance in manufacturing firms on BIST.

Further, our multivariate results reveal that the presence of engineer CEOs has a stronger association with firm performance for manufacturing firms of smaller size. That is, for firms with engineer CEOs, the operating and the market-based performance are higher for

smaller firms. Since CEOs might have stronger influence on smaller firms' operations and corporate outcomes, small firms stand to benefit more from the knowledge and skills of engineer CEOs. Thus, engineer CEOs appear to be more valuable for publicly traded manufacturing firms that still have room for growth.

Our findings are consistent with the results of a recent study by Wang et al. (2016), who conduct an extensive meta-analytic analysis to synthesize prior research on the relation between commonly studied CEO characteristics, firm strategic actions, and firm performance. Wang et al. (2016) find that CEO characteristics such as age, tenure, formal education, and prior career experience are positively related to firm performance. Our paper therefore extends the existing literature on the positive relationship between CEOs and firm performance by showing that this relation also holds for engineer CEOs in manufacturing firms publicly listed on BIST.

Overall, the evidence we provide in our study indicates that manufacturing firms on BIST might benefit from the expertise and experience of engineers in terms of firm performance if these engineers serve as company executives. Our paper therefore complements the CEO literature by documenting that engineer CEOs seem to play a different role than other types of CEOs in manufacturing companies on BIST.

2. LITERATURE REVIEW

The educational background of CEOs and its relation to firm performance have always been a topic of interest both in the business world and the academia. While most evidence of this relation remains anecdotal[2], there are also systematic studies which, however, mainly focus on US companies.

One strand of literature focuses on individual CEO characteristics and considers the educational background of the CEO to be related to corporate performance. By synthesizing existing studies on top management characteristics, Hambrick and Mason (1984) conclude that organizational outcomes, such as strategic choices and performance levels, may be predicted by managerial background characteristics including the formal educational background of the manager. In a recent paper, Kaplan, Klebanov, and Sorensen (2012) conduct an extensive analysis of individual CEO characteristics, and include the education in their analysis as a directly observable CEO characteristic that may significantly affect corporate performance. Martelli and Abels (2010) conduct a detailed descriptive analysis of the CEOs of Fortune 500 companies. Among various demographic variables, they specifically focus on many education-related variables in order to identify the characteristics of these successful business leaders in these powerful companies.

[2] See, for example, Rose and Wong (1989), Chandy (1991), Bolt (1993), Morton (2003), Burrell (2006), O'Donnell (2008), Hansen, Ibarra, and Peyer (2010), Gitsham (2011), Al-Saleh (2014), McGinn (2016).

The existing literature that directly studies the relation between CEO education and firm performance for US firms finds a weak association between them. Using a sample of US firms listed on New York Stock Exchange (NYSE), Gottesman and Morey (2010) find no significant evidence of a relation between the educational background of the CEO and firm financial performance measured by Tobin's Q. Similarly, Bhagat, Bolton, and Subramanian (2011) find no significant relation between CEO education and firm performance measured by ROA and Tobin's Q for companies comprising the Standard & Poor (S&P)'s Composite 1500 Index. Jalbert, Rao, and Jalbert (2002) and Jalbert, Furumo, and Jalbert (2011) study how CEO educational background is related to CEO compensation and firm performance measured by ROA and Tobin's Q for large US firms listed in Forbes magazine in different time windows. Both studies document specific links between CEO education and firm performance.[3]

Another strand of literature studies the relation between CEO education and corporate outcomes other than the firm performance for US companies. For example, Barker and Mueller (2002) examine how research and development (R&D) spending varies at firms based on the characteristics of the CEOs including their educational background. Daellenbach, McCarthy, and Schoenecker (1999) also consider top managers' education to be an important determinant of a firm's commitment to innovation in addition to their work experience. Tyler and Steensma (1998) investigate whether top executives' personal experiences including their educational background affect their assessment of their firms' potential technological alliances. Malmendier and Tate (2008) also classify CEOs according to their educational background and examine its effect on firms' acquisitiveness while controlling for other CEO characteristics as well. Some recent studies look at the relation between CEOs and their firms' effect on the environment. For example, Slater and Dixon-Fowler (2010) find a significant positive association between CEOs with MBAs and corporate environmental performance of S&P 500 firms. Even if their study focuses on CEOs having an MBA degree, their analysis also includes a separate variable to account for the level of educational attainment by the CEO in addition to the variable defining an MBA degree. Similarly, Lewis, Walls, and Dowell (2014) find that CEO characteristics such as education and tenure influence US firms' likelihood to voluntarily disclose environmental information.

Existing literature also examines the relation between CEOs and corporate outcomes for certain specific industries. Chevalier and Ellison (1999) find that mutual funds show higher performance if their managers attended more selective undergraduate institutions, after controlling for factors that could influence the mutual fund performance. Gottesman and Morey (2006) extend the analysis by Chevalier and Ellison (1999) by introducing a much

[3] In some other studies analyzing the effect of CEOs on firm performance and strategic decisions of US firms, where CEO education is not the main focus, the authors control for several CEO background-related variables that might influence the outcome variable, among which CEO education is the most commonly used control variable. See, for example, Zhang and Rajagopalan (2010), Weng and Lin (2014), Hamori and Koyuncu (2015).

finer classification of CEO education and also study the relationship between manager education and mutual fund performance. Walston, Chou, and Khaliq (2010) focus on the education of CEOs in US healthcare sector, and identify individual and organizational characteristics that influence the amount of continuing education CEOs take, where they create a control variable to capture the level of CEO education. Palia (2000) studies CEOs in regulated industries and shows that higher-quality CEOs are less likely to work for regulated industries, where CEO quality is proxied by CEO's education quality. In a recent paper, Iqbal (2015) examines whether CEO education explains the introduction of hedging instruments in the oil and gas industry. King, Srivastav, and Williams (2016) base their analysis on a sample of CEOs at publicly listed US banks, and find that CEO educational attainment, both in terms of level and quality, matters for bank performance.

It is important to note that existing studies might use alternative definitions of CEO educational background. For example, in their study on overconfident CEOs of Forbes 500 companies, Malmendier and Tate (2005) classify CEOs into three groups based on their field of study: CEOs with technical education (engineering or natural sciences), CEOs with finance education (accounting, finance, business, and economics), and CEOs with other degrees (law, literature, etc.). They provide evidence that CEO characteristics other than overconfidence such as CEO education also have explanatory power for corporate decision making. Using a similar classification of CEO education, Ben-Mohamed et al. (2014) show that the investment cash flow sensitivity of financially constrained NYSE industrial firms is affected by various CEO characteristics including CEO education. Similarly, in their work on S&P 1500 firms, Custodio and Metzger (2014) distinguish between CEOs holding different college degrees such as science, economics, and law; and include detailed explanatory variables regarding the education of the CEO in their multivariate models to control for the possibility that CEO education might be one of the important determinants of firms' several financial policies. Lastly, Bach and Smith (2007) characterize CEOs as powerful based on several dimensions including graduation from a prestigious educational institution.

Among research on non-US firms, Graham, Harvey, and Puri (2013) conduct a survey analysis to examine how US CEOs differ from non-US CEOs in terms of behavioral and other characteristics. They gather a number of demographic characteristics of the CEOs relating to personality traits as well as career and education, and find that these characteristics are correlated with corporate decision making. In another non-US study, where firm volatility of large United Kingdom (UK) financial institutions is analyzed, Belghitar and Clark (2012) take CEO education as one of the CEO characteristics that might affect CEO's appetite for risk taking. Hsu, Chen, and Cheng (2013) examine the impact of CEO attributes on the internationalization–performance relationship of small- and medium-sized enterprises in Taiwan and document a moderating effect of CEO educational level.

Compared to the US context, there are relatively fewer studies on the relation between CEOs and corporate outcomes in developing countries context. Most of these studies focus on

China. Wei et al. (2014) explore the relationship between CEO dismissal in China and CEO demographics such as CEO education, age and tenure. Fleisher et al. (2011) estimate how the education level of workers and CEO contributes to firms' total factor productivity in China. Lin et al. (2011) examine the effect of CEO characteristics such as CEO education, CEO professional background and CEO political connections on innovation activities of private Chinese companies. Some other studies on Chinese companies, such as Li and Tang (2010) and Qian, Cao, and Takeuchi (2013), do not have CEO education as their main variable of interest but include it in their models as one of the main control variables related to CEO background. Finally, another work on CEOs and firm performance in developing countries relates to Brazilian companies. Serra, Tres, and Ferreira (2016) include the level of CEO education in their models to estimate firm performance in Brazilian companies, and also distinguish between CEOs with a degree in engineering or science and CEOs with other degrees.

Regardless of the specific country analyzed, one thing that all these various studies have in common, other than focusing on CEO education, is that they employ similar empirical methods. First, univariate analyses are conducted to describe firm financials using summary statistics such as the mean, which are then followed by multivariate analyses. Multivariate models, mostly OLS regressions, are used to investigate the specific relationship between the CEO background-related variable and the corporate outcome variable. If the coefficient estimate of the CEO background-related variable turns out to be significant in the multivariate models, then it indicates the expected change in the corporate outcome variable with respect to a change in this CEO background-related variable while holding all other firm or CEO characteristics constant that might influence the relationship being tested.

In sum, while there are ample of studies that look at the relation between manager characteristics and firm characteristics, the relation between a firm's top management characteristics and its financial performance remains relatively unexplored for BIST companies. In particular, the existence of engineer CEOs in BIST firms and whether they differ from CEOs with other educational background in terms of their contribution to firm performance have not yet been documented in existing literature. To the best of our knowledge, ours is the first systematic study investigating the relation between CEO education and firm performance in BIST firms, therefore complementing the literature on the performance of BIST companies.

Overall, our paper contributes to the literature on the expertise and experience of chief executive officers, which documents significant and positive associations between specific CEO characteristics and firm performance. In this study, we investigate how CEOs' occupational expertise gained from education might affect corporate performance in public firms, specifically in firms in the manufacturing sector traded on BIST, and document a significant and positive association between CEO education and firm performance, therefore supporting the findings in existing literature.

3. DATA AND DESCRIPTIVE STATISTICS

Our sample consists of firms whose shares are traded on Borsa Istanbul; and the sample period covers years from 2009 to 2015. We start our sample period in 2009 because this is the year when the Public Disclosure Platform of Turkey[4] (PDP) started to provide the financial statements of BIST firms on a regular basis. Sector information is also obtained from PDP, with the majority of BIST companies operating in the manufacturing industry. There are a total of 144 firms in the manufacturing industry, with the largest sector being "fabricated metal products, machinery and equipment[5] (MME)" which is comprised of 26 manufacturing firms.

We hand-collect data on company executives, specifically biographical information on CEOs, from companies' annual reports and from various other sources including company websites, company press releases and public news if detailed information on the CEO's educational background is not provided on PDP. We distinguish between CEOs who hold an engineering degree and CEOs who do not hold an engineering degree, whom we denote as "engineer CEOs" and as "non-engineer CEOs", respectively.

Table 1 presents the year distribution of our sample of BIST manufacturing firms, for which we are able to hand-collect information on the educational background of the CEOs. The number of BIST manufacturing firms with engineer CEOs does not show much variation during the sample period, with the percentage of firms with engineer CEOs being 61.6 % each year, on average.

While the majority of our sample firms do not change their CEOs over the sample period, some of them experience CEO turnovers over the sample period. In our analysis, we focus on the educational background of the CEOs and not on their identities. This implies that if a firm is identified as having an engineer CEO during the whole sample period from 2009 to 2015, this does not necessarily mean that there is no CEO turnover during this time period; it simply means that the executive holding the CEO title in this firm is always an engineer during this time period, regardless of whether there is a CEO turnover or not. Similarly, if a firm has three different CEOs during the seven-year sample period, with the first two of them having a non-engineering degree and the last of them having an engineering degree, we identify this as a single switch from a non-engineer CEO to an engineer CEO.

In order to identify a switch of the firm from having a non-engineer CEO to having an engineer CEO and vice versa, we check the majors of executives holding the CEO title in consecutive years. Specifically, if the major of the CEO in year *t* is different from the major of the CEO in year *t+1*, we identify this as a switch of CEO major in year *t*. Here, we do not count a turnover of the CEO as a switch in the major, if the major of consecutive CEOs remains the same.

[4] Kamuyu Aydınlatma Platformu (KAP).
[5] İmalat Sanayi: Metal Eşya, Makine ve Gereç Yapım.

In Table 2, we show the distribution of the educational background of BIST-CEOs in manufacturing firms. We find that among a total of 122 firms, 68 of them, i.e. 55.7% of the BIST manufacturing firms, have an engineer CEO during the whole sample period from 2009 to 2015; whereas 36 of them, i.e. 29.5% of the BIST manufacturing firms, have a non-engineer CEO during the sample period. Eight firms switched from having a non-engineer CEO to having an engineer CEO, whereas ten firms switched from having an engineer CEO to having a non-engineer CEO during the sample period. These descriptive statistics show that engineering is the most common academic degree among CEOs appointed by BIST manufacturing firms.

We observe similar percentages for the MME sector as shown in Table 2. In particular, among a total of 24 firms in this sector, 14 of them, i.e. 58.3%, have an engineer CEO during the whole sample period from 2009 to 2015; whereas 7 of them, i.e. 29.2%, have an non-engineer CEO during the sample period. Two firms switched from having a non-engineer CEO to having an engineer CEO, whereas only one firm switched from having an engineer CEO to having a non-engineer CEO during the sample period.

Firm financials for our sample firms come from Rasyonet database. Table 3 presents the mean values of financial variables within the sample period for all BIST manufacturing firms and also for the subsamples of these firms with versus without engineer CEOs. Of the 730 firm-years in the sample, for which all related firm financials are available, 499 represent those with engineer CEOs, implying that engineer CEOs constitute approximately 68% of the pool of corporate CEOs in the sample.

We find that firms with engineer CEOs have been public for a similar amount of time compared to firms without engineer CEOs. Table 3 shows that, on average, firms with engineer CEOs have been public for 18.5 years whereas firms without engineer CEOs have been public for 17.6 years, the difference not being statistically significant. We analyze several measures of firm size including total assets, market value of assets (MVA), market capitalization (MCAP), and net sales. A comparison of these size measures between firms with engineer CEOs and firms without engineer CEOs does not show a significant difference between these two subsamples of firms. Specifically, the mean of total assets (market value of assets) for firms with engineer CEOs is 1,292 million TRY (1,558 million TRY) compared with 1,114 million TRY (1,471 million TRY) for firms without engineer CEOs, the difference not being statistically significant. On average, these two subsamples of firms also show similar levels of firm growth, as proxied by sales growth, with the difference not being statistically significant.

Taking a market-based performance measure, the Tobin's Q, as a proxy for firms' growth opportunities, we find that firms with engineer CEOs have a slightly higher Tobin's Q of 1.54, on average, compared to firms without engineer CEOs, which have an average Tobin's Q of 1.41, with the difference being statistically significant at the 10% level. Moreover, firms with engineer CEOs also have better operating performance as measured by

return on assets (ROA). Specifically, firms with engineer CEOs have an ROA of 6.39% as compared with 4.17% for firms without engineer CEOs, the difference being statistically significant at the 1% level. These univariate findings point to a positive relation between the presence of engineer CEOs and firm performance in general.

The mean leverage, defined as the debt-to-equity ratio, for firms with engineer CEOs is 1.18 and is higher than 0.77 for firms without engineer CEOs, the difference however not being statistically significant. Finally, Table 3 also shows no significant differences between the two subsamples of firms in the remaining firm characteristics such as intangible assets, R&D expenses, and capital expenditures (CAPEX).

In Table 4, we further analyze the performance of BIST manufacturing firms for each year over the sample period. In almost all years, firms with engineer CEOs perform better than firms with non-engineer CEOs, in terms of both operating performance and market-based performance as shown in Panel A and in Panel B, respectively. The difference in firm performance over the whole sample period is statistically significant at the 1% level and at the 10% level for ROA and for Tobin's Q, respectively, again pointing to a positive relation between engineer CEOs and firm performance.

Overall, our univariate comparison of firm financials between firms with engineer CEOs and firms with non-engineer CEOs reveals that there is no significant difference between these two subsamples of firms in terms of their firm financials except their operating performance and market-based performance, which are higher for firms with engineer CEOs. This finding indicates that these two subsamples of firms are structurally similar and therefore rules out any concern that CEO appointments are not random with respect to some other corporate characteristics. This in turn implies that the presence of an engineer CEO might play the key role in explaining the observed differences in firm performance.

4. MULTIVARIATE ANALYSIS

Our univariate results so far establish a positive association between having CEOs with an engineering background and firm performance for BIST manufacturing firms. In this section, we investigate whether the relation between CEO educational background and firm performance also holds in a multivariate setting. We use two measures of firm performance, namely the return on assets defined as the firm's EBITDA as a percentage of total assets, and Tobin's Q defined as the ratio of market value of assets to book value of assets. Therefore, the dependent variables in our multivariate models are ROA and Tobin's Q. In all our regressions, our main variable of interest is *Engineer_CEO*, which is an indicator variable taking the value of one if the CEO has an educational background in engineering and zero otherwise.

In our multivariate models, we include several firm-level control variables, which the existing literature considers to influence firm performance, such as *Firm Size* defined as the natural logarithm of total assets, *Firm Public Age* defined as the natural logarithm of the

number of years since the firm's initial public offering, *Sales Growth* defined as the ratio of the change in net sales to previous year's net sales, *Intangible Assets* defined as the ratio of intangible assets to total assets, *Free Cash Flow* defined as the firm's free cash flow divided by net sales, *Leverage* defined as the ratio of total debt to total equity, *R&D Expenses* defined as the research and development expenses as a ratio of net sales, *CAPEX* defined as the capital expenditures divided by total assets, and *Marketing Expenses* defined as the firm's marketing expenses divided by total assets. We also include the interactions of our main variable of interest *Engineer_CEO* with *Firm Size* and *Firm Public Age*. ROA regressions also include Tobin's Q as an additional control variable. Finally, all our models include year fixed effects and are estimated using robust standard errors to correct for heteroskedasticity.

We estimate the following multivariate models for our panel dataset over seven years, where *i* denotes the sample firms and *t* denotes the years:

$$ROA_{it} = \alpha + \beta_1 Engineer\_CEO_{it} + \beta_2 Firm\ Size_{it} + \beta_3 Firm\ Public\ Age_{it} + \beta_4 Engineer\_CEO_{it} * Firm\ Size_{it} + \beta_5 Engineer\_CEO_{it} * Firm\ Public\ Age_{it} + \beta_6 Tobin's\ Q_{it} + \beta_7 Sales\ Growth_{it} + \beta_8 Intangible\ Assets_{it} + \beta_9 Free\ Cash\ Flow_{it} + \beta_{10} Leverage_{it} + \beta_{11} R\&D\ Expenses_{it} + \beta_{12} CAPEX_{it} + \beta_{13} Marketing\ Expenses_{it} + Year\ Dummy_t + \varepsilon_{it}$$

$$Tobin's\ Q_{it} = \alpha + \beta_1 Engineer\_CEO_{it} + \beta_2 Firm\ Size_{it} + \beta_3 Firm\ Public\ Age_{it} + \beta_4 Engineer\_CEO_{it} * Firm\ Size_{it} + \beta_5 Engineer\_CEO_{it} * Firm\ Public\ Age_{it} + \beta_6 Sales\ Growth_{it} + \beta_7 Intangible\ Assets_{it} + \beta_8 Free\ Cash\ Flow_{it} + \beta_9 Leverage_{it} + \beta_{10} R\&D\ Expenses_{it} + \beta_{11} CAPEX_{it} + \beta_{12} Marketing\ Expenses_{it} + Year\ Dummy_t + \varepsilon_{it}$$

4.1. Return On Assets

Table 5 presents estimation results of OLS regressions, where the dependent variable is the return on assets defined as EBITDA as a percentage of total assets. Model (1) provides the coefficient estimates for the basic model where we only include our main variable of interest *Engineer_CEO* and year fixed effects. The coefficient on *Engineer_CEO* is positive and statistically significant at the 1% level indicating that the presence of an engineer CEO is positively related to the firm's operating performance measured by ROA. Based on model (1), the presence of an engineer CEO is associated with ROA that is higher by 1.77%. This effect is economically large given that the average ROA is 5.69% in our overall sample.

When we include firm size and firm public age as firm-level control variables together with their interactions with *Engineer_CEO* in model (2) of Table 5, we verify our main result of a positive association between the presence of an engineer CEO and firm performance measured by ROA. The coefficient on *Engineer_CEO* is positive and statistically significant

at the 1% level, and we find that the presence of an engineer CEO is associated with ROA that is higher by 14.90%. In addition, in model (2), we find that the coefficient on the interaction term between *Engineer_CEO* and *Firm Size* is negative and statistically significant at the 1% level. Specifically, the point estimate implies that ROA decreases by 1.63% for a one-standard-deviation increase in firm size from its mean level for firms with engineer CEOs. This finding indicates that the positive relation between the presence of an engineer CEO and operating performance that we document is more pronounced for smaller firms, that is, for firms that stand to benefit more from the knowledge and skills of engineer CEOs. Finally, the coefficient on the interaction term between *Engineer_CEO* and *Firm Public Age* is positive but not statistically significant.

In models (3)-(5) of Table 5, we include additional firm-level control variables that are found to have a significant effect on operating performance in existing literature. In all these models, the coefficient on *Engineer_CEO* is positive and statistically significant at the 1% level verifying our main result of a positive association between the presence of an engineer CEO and operating performance. Based on model (5), where we include all control variables, having an engineer CEO is associated with a 17.36% increase in ROA. Moreover, we also find that this relation is stronger for smaller firms as indicated by the negative and statistically significant coefficient of the interaction between *Engineer_CEO* and *Firm Size*. Finally, we also find that larger firms, firms that have been public for a shorter time period, firms with higher Tobin's Q, lower level of intangible assets and lower leverage are associated with higher ROA.

4.2. Tobin's Q

In Table 6, we present estimation results of OLS regressions, where the dependent variable is Tobin's Q defined as the ratio of market value of assets to book value of assets. Model (1) shows the coefficient estimates for the basic model where only the main variable of interest *Engineer_CEO* and year fixed effects are included. The coefficient on *Engineer_CEO* is positive and statistically significant at the 10% level, which shows that the presence of an engineer CEO is positively related to the firm's market performance measured by Tobin's Q. Based on model (1), the presence of an engineer CEO is associated with Tobin's Q that is higher by 0.12, which is an economically meaningful effect given that the average Tobin's Q is 1.50 in our overall sample.

In model (2) of Table 6, we include firm size and firm public age as firm-level control variables together with their interactions with *Engineer_CEO*. We verify our main result of a positive association between the presence of an engineer CEO and firm performance measured by Tobin's Q. The coefficient on *Engineer_CEO* is positive and statistically significant at the 1% level, and shows that the presence of an engineer CEO is associated with Tobin's Q that is higher by 1.52. In addition, in model (2), we find that the coefficient on the interaction term between *Engineer_CEO* and *Firm Size* is negative and statistically significant

at the 1% level. The point estimate implies that, for firms with engineer CEOs, Tobin's Q decreases by 0.22 for a one-standard-deviation increase in firm size from its mean level. This finding indicates that the positive relation between the presence of an engineer CEO and market performance that we observe is stronger for smaller firms, which are firms that are expected to benefit more from the knowledge and skills of engineer CEOs.

Finally, in model (2) of Table 6, the coefficient on the interaction term between *Engineer_CEO* and *Firm Public Age* is positive and statistically significant at the 1% level. The point estimate implies that Tobin's Q increases by 0.11 for a one-standard-deviation increase in firm public age from its mean level for firms with engineer CEOs. This finding implies that the documented relation between the presence of an engineer CEO and market performance is stronger for firms that have been public for a longer time period. This suggests that, in terms of market-based firm performance, having an engineer CEO is more beneficial the more mature a public firm is.

We include several additional firm-level control variables in models (3)-(5) of Table 6, which are shown to have a significant effect on a firm's market performance in existing literature. The coefficient on *Engineer_CEO* is positive and statistically significant at the 5% level in all these models verifying our main result that there is a positive association between the presence of an engineer CEO and the firm's market performance. Model (5) includes all control variables and shows that having an engineer CEO is associated with an increase in Tobin's Q of 1.49. We continue to observe that this relation is stronger for smaller firms and for firms that have been public for a longer period of time as indicated by the negative and statistically significant coefficient of the interaction between *Engineer_CEO* and *Firm Size*, and positive and statistically significant coefficient of the interaction between *Engineer_CEO* and *Firm Public Age*, respectively. Finally, we also find that firms which have lower R&D expenses and firms with a higher level of marketing expenses are associated with higher Tobin's Q.

Overall, our multivariate results show that the educational background of CEOs is significantly related to firm performance. Specifically, having engineers as CEOs is associated with higher firm performance as measured by ROA and Tobin's Q for BIST manufacturing firms. The association between engineer CEOs and firm performance is robust to the inclusion of several firm-level control variables that are considered to have an important effect on firm performance in existing literature. Moreover, we find that that the presence of engineer CEOs has a stronger association with firm performance for firms of smaller size and for firms that have been public for a longer period of time. These findings suggest that, due to their technical skills and related operational expertise, engineer CEOs may make better decisions regarding the firm's operations compared to other CEOs of different backgrounds. Therefore, manufacturing firms managed by engineer CEOs might show better overall firm performance.

5. CONCLUSION

While the relation between manager characteristics and firm characteristics has been studied extensively for large public companies in developed countries, the relation between a firm's top management characteristics and its financial performance remains relatively unexplored for companies traded on Borsa Istanbul – the stock market of Turkey.

In this study, we focus on a specific type of CEO in public firms traded on BIST, namely "engineer CEOs" who have an educational background in engineering, and examine the relation between these engineer CEOs and firm performance. We show that, in manufacturing firms publicly traded on BIST, the presence of an engineer CEO is associated with higher firm performance. Our finding holds for both operating performance as well as market-based performance, measured by return on assets and Tobin's Q, respectively. Moreover, our results also hold after we include several firm-level control variables in our multivariate analyses.

The positive association between having CEOs with an engineering background and firm performance that we document for BIST manufacturing firms is shown to be more pronounced for firms of smaller size. Thus, engineer CEOs appear to be more valuable for publicly traded firms that still have room for growth. Our study therefore complements the findings of existing literature on the importance of CEOs' skills and experience for better company performance.

Overall, we document that manufacturing firms traded on BIST show better operational as well as market-based performance when they are managed by CEOs with an educational background in engineering than by CEOs with other educational backgrounds. Therefore, our findings lend support for the view that CEOs with an engineering background benefit manufacturing firms in terms of operating performance and market-based performance through their guidance and expertise. More generally, our results indicate that CEO education is relevant for corporate performance of BIST companies.

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Table 1. Year Distribution of BIST Manufacturing Firms over 2009-2015

Year	Number of all manufacturing firms	Number of manufacturing firms with engineer CEOs	Percentage of manufacturing firms with engineer CEOs
2009	120	78	65.00
2010	120	76	63.33
2011	121	76	62.81
2012	121	71	58.68
2013	121	74	61.16
2014	120	74	61.67
2015	120	70	58.33

Table 2. Descriptive Statistics For Educational Background of BIST-CEOs over 2009-2015

Number of firms:	All manufacturing firms	MME manufacturing firms
Firms with engineer CEOs	68	14
Firms with non-engineer CEOs	36	7
Firms that switch from a non-engineer CEO to an engineer CEO	8	2
Firms that switch from an engineer CEO to a non-engineer CEO	10	1
Total	122	24

Table 3. Firm Financials for BIST Manufacturing Firms

With Versus Without Engineer CEOs

	All Firms		Firms with engineer CEOs		Firms with non-engineer CEOs		t-statistic
	N	Mean	N	Mean	N	Mean	
Firm Public Age	730	18.23	499	18.52	231	17.60	1.47
Total Assets (million TRY)	730	1,235.68	499	1,292.11	231	1,113.76	0.82
MVA (million TRY)	730	1,530.39	499	1,558.07	231	1,470.61	0.31
MCAP (million TRY)	730	1,033.89	499	1,049.90	231	999.32	0.28
Net Sales (million TRY)	730	1,305.47	499	1,414.22	231	1,070.56	1.39
Sales Growth	730	0.15	499	0.14	231	0.17	-0.66
Tobin's Q	730	1.50	499	1.54	231	1.41	1.74*
Return on Assets (%)	730	5.69	499	6.39	231	4.17	3.20***
Leverage	730	1.05	499	1.18	231	0.77	1.55
Intangible Assets (as % of Total Assets)	730	1.94	499	1.90	231	2.04	-0.35
R&D Expenses (as % of Net Sales)	730	0.38	499	0.40	231	0.34	1.17
Capital Expenditures (as % of Total Assets)	730	4.96	499	4.84	231	5.23	-0.73

Table 4. Annual Firm Performance for BIST Manufacturing Firms With Versus Without Engineer CEOs

Panel A: ROA				
	Firms with engineer CEOs		**Firms with non-engineer CEOs**	
Year	**N**	**Mean**	**N**	**Mean**
2009	77	4.07	35	2.74
2010	76	5.44	38	5.53
2011	76	7.74	41	4.93
2012	71	6.02	41	5.92
2013	73	5.60	43	4.82
2014	73	8.97	42	5.51
2015	69	7.07	39	3.80
2009-2015	515	6.41	279	4.71
Panel B: Tobin's Q				
	Firms with engineer CEOs		**Firms with non-engineer CEOs**	
Year	**N**	**Mean**	**N**	**Mean**
2009	74	1.27	27	1.17
2010	74	1.90	28	1.40
2011	75	1.49	31	1.33
2012	70	1.70	35	1.54
2013	73	1.47	39	1.40
2014	73	1.59	42	1.61
2015	69	1.40	39	1.42
2009-2015	508	1.55	241	1.42

Table 5. Engineer CEOs and Operating Performance

	ROA				
	1	**2**	**3**	**4**	**5**
Engineer_CEO	1.77***	14.90***	15.27***	16.78***	17.36***
	(2.57)	(2.49)	(2.70)	(2.99)	(3.05)
Firm Size		1.94***	2.29***	2.44***	2.55***
		(4.57)	(5.79)	(6.16)	(5.88)
Firm Public Age		-1.39***	-1.58***	-1.64***	-1.81***
		(-2.48)	(-2.86)	(-2.94)	(-2.92)
Engineer_CEO*Firm Size		-1.35***	-1.36***	-1.49***	-1.55***
		(-2.74)	(-2.93)	(-3.20)	(-3.21)
Engineer_CEO*Firm Public Age		1.76	1.62	1.73	1.88
		(1.23)	(1.17)	(1.25)	(1.35)
Tobin's Q			1.84***	1.81***	1.83***
			(3.55)	(3.54)	(3.53)
Sales Growth			0.96	0.97	0.96
			(0.97)	(0.93)	(0.93)
Intangible Assets			-20.96***	-20.22***	-20.58***
			(-3.36)	(-3.26)	(-3.25)
Free Cash Flow				-0.06	-0.07
				(-0.94)	(-1.11)
Leverage				-0.48**	-0.51**
				(-2.22)	(-2.28)
R&D Expenses					59.62
					(1.00)
CAPEX					-7.65
					(-1.08)
Marketing Expenses					3.51
					(0.69)
Year2010	1.85	1.49	0.42	0.34	0.42
	(1.57)	(1.38)	(0.38)	(0.31)	(0.38)
Year2011	3.25***	3.26***	2.60**	2.68**	2.82**
	(2.57)	(2.56)	(1.99)	(2.07)	(2.16)
Year2012	2.52**	2.10*	1.12	1.16	1.26
	(2.04)	(1.73)	(0.97)	(1.01)	(1.10)
Year2013	1.89	1.15	0.47	0.50	0.59
	(1.47)	(0.97)	(0.40)	(0.42)	(0.49)
Year2014	4.31***	3.73***	2.67**	2.72**	2.91***
	(3.57)	(3.12)	(2.27)	(2.34)	(2.46)
Year2015	2.35**	1.79	1.17	1.50	1.67
	(1.93)	(1.48)	(1.01)	(1.32)	(1.45)
Constant	2.34***	-19.11***	-24.79***	-26.20***	-27.40***
	(2.53)	(-3.95)	(-5.48)	(-5.85)	(-5.76)
Adjusted R^2	**0.02**	**0.05**	**0.11**	**0.13**	**0.13**
Sample Size	**799**	**740**	**730**	**730**	**730**

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Engineer CEOs and Market-Based Firm Performance

	Tobin's Q				
	1	**2**	**3**	**4**	**5**
Engineer_CEO	0.12*	1.52***	1.29**	1.33**	1.49**
	(1.68)	(2.48)	(2.10)	(2.19)	(2.46)
Firm Size		0.01	-0.02	-0.02	0.005
		(0.41)	(-0.54)	(-0.44)	(0.11)
Firm Public Age		0.005	0.02	0.02	-0.04
		(0.09)	(0.37)	(0.35)	(-0.58)
Engineer_CEO*Firm Size		-0.18***	-0.16***	-0.16***	-0.17***
		(-3.61)	(-3.13)	(-3.23)	(-3.57)
Engineer_CEO*Firm Public Age		0.34***	0.30**	0.31**	0.34***
		(2.55)	(2.29)	(2.31)	(2.55)
Sales Growth			-0.05	-0.05	-0.05
			(-1.35)	(-1.36)	(-1.22)
Intangible Assets			2.02	2.04	1.88
			(1.54)	(1.54)	(1.39)
Free Cash Flow				-0.006	-0.005
				(-1.38)	(-1.13)
Leverage				-0.01	-0.01
				(-0.71)	(-0.67)
R&D Expenses					-12.38**
					(-2.18)
CAPEX					0.48
					(0.38)
Marketing Expenses					1.46**
					(2.15)
Year2010	0.52***	0.48***	0.50***	0.50***	0.49***
	(2.88)	(2.72)	(2.74)	(2.71)	(2.69)
Year2011	0.20*	0.22*	0.22*	0.22*	0.21
	(1.66)	(1.70)	(1.69)	(1.70)	(1.62)
Year2012	0.41***	0.42***	0.42***	0.42***	0.41***
	(2.79)	(2.80)	(2.82)	(2.82)	(2.67)
Year2013	0.21*	0.22*	0.22*	0.23*	0.22*
	(1.66)	(1.68)	(1.74)	(1.74)	(1.75)
Year2014	0.37***	0.35***	0.37***	0.37***	0.35***
	(3.14)	(2.95)	(3.05)	(3.06)	(2.94)
Year2015	0.17	0.18	0.20*	0.21*	0.21*
	(1.54)	(1.57)	(1.70)	(1.77)	(1.76)
Constant	1.15***	0.96**	1.32***	1.28***	1.03**
	(15.10)	(2.34)	(2.77)	(2.69)	(2.04)
Adjusted R^2	**0.01**	**0.05**	**0.05**	**0.05**	**0.05**
Sample Size	**755**	**737**	**730**	**730**	**730**

***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.