Exploring the Impact of Board Size on Financial Performance of Healthcare Companies: An Empirical Analysis[1]

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Abstract:

The board of directors of a firm is a group of individuals who are elected or appointed by shareholders to provide suggestions and supervision to the management for public companies. However, the cost of having a board of directors can be significant. To evaluate the effects of the board of directors on a firm's performance and provide firms with the optimal board size, this paper employs simple and multiple linear regression along with the marginal effect analysis to research the relationship between board size and financial performance for large public healthcare companies. Our findings suggest a significant negative relationship between ROA and board size after controlling for other variables, indicating an increase in board size is associated with a decrease in the firm's profitability on average in the given range.

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Introduction

For public companies, the board of directors are elected by shareholders of the company and they serve as providing suggestions and supervision to the management team. The board of directors is typically composed of a mix of independent directors, who are not employees of the company, and executive directors, who are senior managers of the company. Despite its necessity, the cost of having a board is huge. For example, the board of directors can take hundreds of millions dollars every year as their salaries, and the cost of preparing reporting documents is also not negligible. Therefore, we try to find the relationship between the board size and firm performance in terms of profitability in the healthcare industry, and whether there is an optimal board size that can maximize the shareholders' benefit. Empirically, more board of directors can provide more professional suggestions and supervision on management's operation, thus supporting the profitability of the firm. On the other hand, having a large board size is more liable to be subject to the increasing coordination cost, free rider problems (Jensen, 1993), and less likely to have a common purpose (Lipton & Lorsch, 1992). Interestingly, those two possible predictions are viable, as literature reviews suggested[2]. One of the researchers' targets is to find appropriate methods to solve the endogeneity. By far, one of the most reliable methods to tackle this particular topic is to employ a generalized method of moments (GMM) estimator in the regression model (Wintoki, 2007). However, finding the optimal board sizes is out of the researcher's spectrum. Therefore, we decided to find the relationship between board size and firm profitability among large public healthcare companies and find the optimal board size that maximizes shareholders' interest.

Context and Data

We begin our research and analysis by drawing data from two sources: Capital IQ and Wharton Research Data Services. In order to find listed S&P 500 healthcare companies, we combine datasets from two sources for the calendar year 2021. From Capital IQ, we retrieved listed companies' total equity, long-term net debt, calendar year R&D expense, and calendar year EBIT. From WRDS, we retrieved data on listed companies' board size and Return on Asset

[2] Mostly find that smaller boards are better, but there are some findings that find the opposite and more nuanced results. For example, Daily & Dalton (1994) and Hillman & Dalziel (2003).

(ROA). The population of interest is large public healthcare companies, therefore, we can use the S&P 500 listed healthcare companies as a sample. By the year ended Jan 1, 2023, there were 64 listed healthcare companies in the S&P 500. After combining those 64 companies' own financial information, we eliminated 21 companies due to missing values that will affect the result. The sample size is large such that it can support the central limit theorem and other statistical requirements[3].

A firm's board size is measured by the number of people on the board with the variable 'bdsize' in the dataset. Among the sample, the board size ranges from 6 people to 14 people with a mean of 10. For interpretation and comparability purposes, we employed the logarithm of board size. With the log form, we interpret the coefficient as one percentage point change in board size will lead to what extent change in firm performance. For comparability purposes, previous researchers commonly found that the relationship between board size and firm performance is not linear (Yermack, 1996). However, the spread of points on the scatterplot in our sample does not provide enough information to determine the presence of curvature. To measure the firm's performance, we used ROA (return on asset) which has been recognized as a common measurement of the firm's performance (Guest, 2009). The ROA is a ratio that indicates a company's profitability in relation to its total assets. The higher ROA a company has, the better performance it has. It is worth noting that the ROA is a ratio, for the purpose of understandability, we multiplied the raw data (ROA) by 100. Therefore, the minimum ROA of those 43 individual samples is 1.79 % and the maximum ROA is 49.46 %. Total equity is a company's total assets minus total liabilities, which can be considered as the net worth of a company under accounting standards. It can also be considered as a measurement of a company's size. Long-term net debt has a range between -17,020 million and 55,354 million. The negative number indicates that the company possesses more immediately available assets than its financial liabilities, and thus is more financially stable. Research and development (R&D) expense is one of the major capital outflows of healthcare companies, the mean is 3,820.6 million and ranges from 21 million to 15,614 million. EBIT is the earnings before income tax and interest expenses, and it ranges from 265.8 million to 26980 million.

[3] When each individual underlying Y variable itself has a distribution that is far from normal, the approximation can require n = 30 or even more. (Stock, Watson Introduction to Econometrics)

Regression Analysis

- Simple Linear Regression

Our baseline model focuses on the relationship between board size and the firm's financial performance. Therefore, we employed the simple linear regression via the following equation:

$$\text{ROA} = \beta_0 + \beta_1 * logbdsize + \epsilon$$

Where the independent variable is the log-transformed board size which is measured by the number of people, and the dependent variable is the ROA that is used to measure the firm's profitability. The robust standard errors are used to eliminate heteroscedasticity.

To interpret the result of regression (1) in table 2, we found there is a negative relationship between the board size and company profitability. The coefficient of the board size is -17.38, which can be interpreted as when there is a 10% increase in the board size, the ROA will decrease by 1.738 percentage points on average. We expect a 95% confidence interval with an average decrease between 2.98 percentage points and 0.5 percentage points in ROA. The result is highly statistically significant at a 99% level as the P-value equals 0.007. Therefore, we reject the null hypothesis that $\beta_1 = 0$. At the same time, the result is also economically significant, as the mean of the ROA in our sample is 12.58%. However, due to the infeasibility to run a controlled experiment in which treatment (logbdsize) is randomly assigned, possible omitted variable biases exist. The correlation between other variables affects the direction of bias in the coefficient of the SLR model.[4] Intuitively, a company's board size and profitability can both be affected by other variables such as the size of the firm. With a bigger firm size, it is more probable that the firm can acquire more customers and thus have more market power, ending up having a higher profitability ratio. As a result of the large size, shareholders of the company tend to elect more board of directors (Yermack & D., 2012). Apart from the size of the firm, how the company finances their business and their business model can also affect both board size and profitability. In the real world due to the cost of borrowing, tax incurred from corporate income, and information asymmetry, the market value would be different when it comes to debt-financing and

[4]The direction of bias depends on the correlation between omitted variables and board size, and the sign of the coefficient of SLR.

equity-financing according to the Modigliani-Miller (MM) theory (Modigliani & Miller, 1958). Usually, the debt-financing would provide a corporation with more tax advantages than equity-financing. The last thing that we would like to control in this research paper is the business model that different companies employ. One of the common business models that a healthcare company employs is to develop new products through heavily investing in R&D. On the other hand, one company can gain access to selling other companies' products by setting up a special purpose entity through an agreement. Therefore, we would like to control for this business model effect as well since the business model affects board size at the same time (Johnson et al, 1996).

- Multiple Linear Regression

We want to get an unbiased estimate of the effect of the board size on ROA, by holding constant factors such as the market power of the firm, finance method, and business model. However, those variables are not readily measured in an accurate figure, and we can only include control variables which are correlated with those omitted causal factors respectively, but which themselves are not causal.

The total equity of the firm, long-term debt size, and R&D cost are correlated with market power, finance method, and business model respectively. We include those factors in the regression as control variables and eliminate the possibility of multicollinearity based on the coefficient matrix (table 4). By assuming the LSA assumptions hold, we set the equation as follows:

$$ROA = \beta_0 + \beta_1 * logbdsize + \beta_2 * TotalEquity + \beta_3 * LTMNetDebt + \beta_4 * RDExpense + \epsilon$$

We've found that after we include those control variables, the result is consistent with the simple linear regression. The negative slope of logbdsize decreased from -17.38 to -15.68. The confidence interval is -28.99 to -2.378 with 95% confidence. It is interpreted as when there is a 10% increase in the board size, the ROA decreases by 1.57 percentage points on average after controlling for total equity, long-term net debt, and R&D cost. It is both statistically and economically significant. The coefficient of -15.68 implies that expanding a ten-person board by

one member implies a reduction in profitability of 1.49 percentage points on ROA. This change is significant as the average listed healthcare company in the S&P 500 has an average total asset equal to 45160.9 million, one extra person will cause a loss of about 672 million[5].

- Extension Analysis

So far, we have analyzed the potential causal effect of board size on firm performance. However, the remaining problem is yet to be resolved: what is the optimal board size for a large public healthcare company? Therefore, we would use dummy variables with multiple categories of different numbers of people on the board to explore the optimal size.

Since the independent variable board size is a discrete variable, we assign each specific board size as a dummy variable. The minimum board size is 6 and the maximum board size is 14. Therefore, we would have 8 dummy variables excluding the size of 6 people as a reference category. From the regression, we can see the marginal effect of expanding one person of a six-person board. From the regression coefficients (regression (3) in table 2) and the margins plot (figure 2), we found that there is an increase in ROA when expanding one person from a six-person board, followed by consistent decreases in ROA when expanding extra people. Therefore, we would conclude that the optimal board size for public healthcare companies would be around seven people.

When considering which metrics to use for measuring a company's performance, an important question is: what is a reliable indicator of profitability for the firm? There are multiple financial and accounting measurements such as gross profit margin, operating profit margin, return on asset (ROA), return on equity (ROE), and earnings before interest and tax (EBIT). However, the literature reviews across the years have been using only a few metrics such as ROA, Tobin's Q, and share return (Yermack 1996, Guest, 2009). Therefore, to test whether we can find other possible metrics to appropriately measure profitability, we adopted the EBIT. However, the regression analysis produced the opposite result: the board size is positively related to the firm performance (table 3). The result is neither statistically significant nor economically significant

[5] This is calculated as follows: the log of 11 (2.398) minus the log of 10 (2.30) is 0.095, which is multiplied by the coefficient of -15.68 gives -1.49. This multiplied by the average asset size of $45,160.9 million gives 672 million.

after controlling for total equity, long-term net debt, and R&D expenses. The reason behind the failure of measuring the firm performance by EBIT is potentially due to the fact that EBIT is calculated by subtracting all operating expenses, except for interest and taxes, from the total revenue. In other words, the EBIT only measures the operating profitability whereas the ROA is calculated from net income, which is a measure of a company's overall profitability. Therefore, the measurement of company performance in terms of profitability is sensitive in regression settings.

Limitation of the results

The type of dataset that we used to produce regression analysis is cross-sectional, where the most desirable dataset type is panel data that supports fixed-effect analysis. In terms of the method we've adopted, OLS single linear regression and multiple linear regression are not the most optimal choice. Many literature reviews adopted GMM and fixed effect methods that produced consistent results as our research suggested (the negative relationship between board size and firm performance), but with different quantitative results. Apart from that, the choice of control variables can be refined. Due to heteroscedasticity, we were unable to test the controlling effectiveness by using the Frisch-Waugh Theorem. Last but not the least, internal validity such as absent controls and simultaneous causality are possible yet we were unable to resolve it by far.

Conclusion

This report analyzes the relationship between board size and a company's profitability for large public healthcare companies. It shows that the increase in board size has a negative effect on the firm's profitability with hundreds of millions of dollars decreasing net income. Apart from that, the optimal board size for a large public healthcare company is approximately seven people based on the marginal effect analysis. The control for firm-specific characteristics is necessary and therefore included in the multiple linear regression considering the fact that companies are not completely similar in the industry. However, due to the limited access to the data and potential threats of internal validity, the results of the analysis can be biased. Those limitations

motivate us to dig deeper with more comprehensive data and reliable statistics tools and refine the results as well as the quality of the research.

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Table 1: Descriptive Statistics for Variables Used in the Analysis (two decimals)

Variable	Number of Observation	Mean	Median	Standard Deviation	Minimum	Maximum
Board Size	43	10.32	10.00	1.89	6.00	14.00
Log of Board Size	43	2.32	2.30	0.19	1.79	2.64
ROA	43	12.58	9.64	9.91	1.71	49.46
Total Equity	43	14863.15	9121	17907.66	-787.00	77463.00
Long-term Net Debt	43	6950.95	2625.2	12709.64	-17020.00	55354.00
R&D Expenses	43	2464.49	671	3820.61	21.00	15614.00
EBIT	43	5118.97	1824	6676.06	265.80	26980.00

Note: This table reports summary statistics for the S&P 500 healthcare company sample. ROA is the ratio of net income divided by total assets, for the purpose of understandability, the actual ROA ratios are multiplied by 100 in the sample data. Board Size is measured by the number of people on the board, and the Log of Board Size is the log-transformed data of Board Size. Total Equity represents the amount of funds that the company's shareholders have contributed to the company through stock issuance and retained earnings. Long-term Net Debt is the amount of debts such as bonds or bank loans due in more than one year, eliminating immediately available assets including cash and cash equivalents. R&D Expenses is research and development cost incurred; EBIT is earnings before interest and tax. All measured in millions of dollars as of the calendar year 2021.

Table 2: Regression Analysis of the Board Size Effects on Return on Asset

Dependent Variable: ROA (multiplied by 100)	Regression (1)	Regression (2)	Regression (3)
Log of Board Size	**-17.3832*** **	**-15.6833** **	
	(6.1467)	(6.5726)	
Total Equity		**-0.0000**	
		(0.0001)	
Long-term Net Debt		**-0.0004** **	
		(0.0002)	
R&D Expense		**0.0012** **	
		(0.0005)	
Board Size of 7			**6.7680*** **
			(0.0000)
Board Size of 8			**-6.4280** **
			(2.9529)
Board Size of 9			**-11.7509***
			(6.1276)
Board Size of 10			**-12.0386*** **
			(2.9401)
Board Size of 11			**-13.6162*** **
			(1.9642)
Board Size of 12			**-12.7746*** **
			(3.7174)
Board Size of 13			**-16.0568*** **
			(1.6854)
Board Size of 14			**-12.4325*** **
			(0.0131)
Controls for other things	No	Yes	No
Adjusted R-Squared	0.1098	0.3286	0.1736
Number of Observations	43	43	43

Notes: This table reports the regression results from three separate models. The data are from two sources: Capital IQ and Warton Research Data Services. All variables are measured as of the calendar year 2021. The dependent variable is the Return on Asset ratio multiplied by 100 for understandability purposes. While Board Size is measured by the number of people on the board ranging from 6 to 14 people in the sample, variable Log of Board Size measures the log-transformed data of Board Size. Total equity is a company's total assets minus total liabilities. Long-term Net Debt is the amount of debts such as bonds or bank loans due in more than one year, eliminating immediately available assets. R&D Expense is the expenditures incurred on research and development in the year 2021. The remaining variables (i.e. Board Size of 7...Borad Size of 14) are dummy variables used in regression(3) representing the exact number of people on the board, board size of 6 is left out as a reference category. Robust standard errors are represented in parentheses.
***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level.

Table 3:

Dependent Variable: EBIT	Regression (1)	Regression (2)
Log of Board Size	**18043.210*** **	**1151.116**
	(5117.944)	(2405.394)
Total Equity		**0.155*** **
		(0.045)
Long-term Net Debt		**0.043**
		(0.099)
R&D Expense		**0.847*** **
		(0.228)
Controls for other things	No	Yes
Adjusted R-Squared	0.2602	0.8194
Number of Observations	43	43

Notes: This table reports the regression results from simple linear model and multiple linear model. The data are from two sources: Capital IQ and Warton Research Data Services. All variables are measured as of the calendar year 2021. The dependent variable is the EBIT which measures the earnings before income tax and interest expenses. While Board Size is measured by the number of people on the board ranging from 6 to 14 people in the sample, variable Log of Board Size measures the log-transformed data of Board Size. Total equity is a company's total assets minus total liabilities. Long-term Net Debt is the amount of debts such as bonds or bank loans due in more than one year, eliminating immediately available assets. R&D Expense is the expenditures incurred on research and development in the year 2021. Robust standard errors are represented in parentheses.

***Significant at the 1% level. **Significant at the 5% level. *Significant at the 10% level.

Table 4: Correlation Matrix of Independent Variables

	ROA	Board Size	Log of Board Size	Total Equity	Long-term Net Debt	R&D Expense	EBIT
ROA	1.0000						
Board Size	-0.3094	1.0000					
Log of Board Size	-0.3313	0.9929	1.0000				
Total Equity	-0.1058	0.5177	0.4836	1.0000			
Long-term Net Debt	-0.4510	0.4180	0.4085	0.4254	1.0000		
R&D Expense	-0.0742	0.5333	0.5009	0.7347	0.5885	1.0000	
EBIT	0.0681	0.5328	0.5101	0.8231	0.5572	0.8550	1.0000

Figure 1: Diagnostic Plot of Log of Board Size and ROA

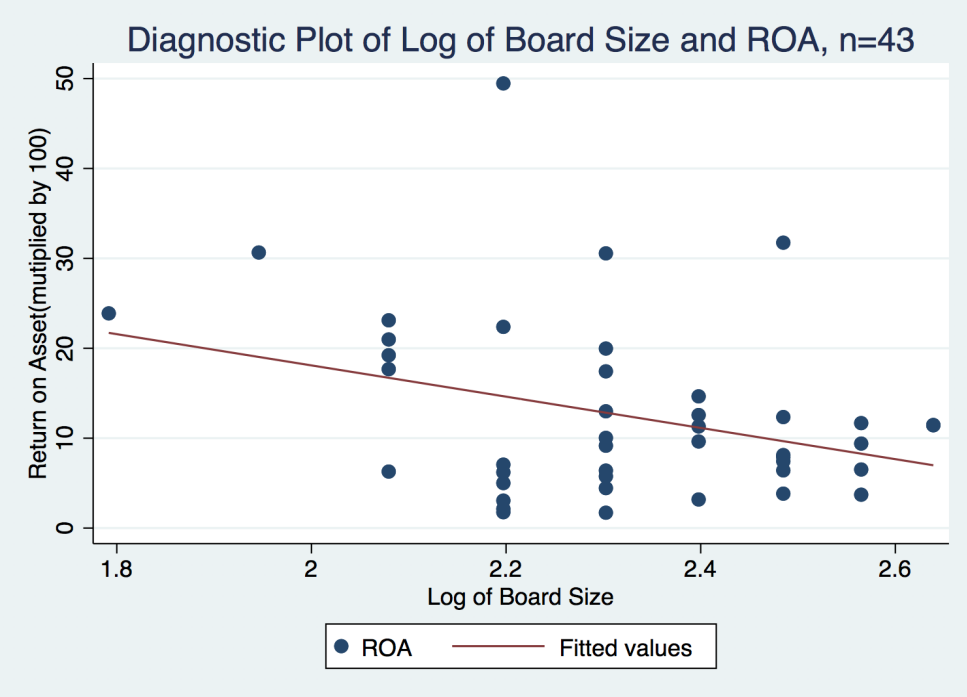

Figure 2: Estimated Board Size Effects on ROA