Exploring Firms Value Efficiency: Empirical investigation into intellectual capital of firms and financial parameters

By

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Executive Summary

As the world move towards knowledge based economy, it becomes increasingly important to understand and value intangible assets of a firm. In order to understand these intangible assets, it is important to understand their value generation ability. In other words, one way to know these intangible assets of a firm is to understand their efficiency in value creation. A. Pulic, devised an firm efficiency measurement called value added intellectual coefficient (VAIC). This index looks beyond the traditional accounting method and calculates overall resource utilization efficiency of a firm. This efficiency index in turn, reflects on the intellectual capital of a firm. VAIC as described by A. Pulic, is made on three efficiency components human capital efficiency (HCE), structural capital efficiency (SCE) and capital employed efficiency (CEE). Since the publication of VAIC methodology, researchers have tried to understand whether this efficiency index of VAIC correlates with traditional firm performance like its market valuation (M/B) and return on equity (ROE). A good correlation between VAIC and dependent variables like M/B and ROE will help investors (stakeholders) to understand intellectual capital of a firm. This understanding of firm efficiency can help an investment firm or an investor to make better investment decision. In this thesis, a multilinear regression approach was adopted to investigate correlation between independent variables like (VAIC,HCE, SCE and CEE) and dependent variables like market valuation (M/B) and return on equity (ROE). In addition, two moderating variables (age of firm and size of firm) were also explored. These variables were selected because of learning effect theory ; as firm grows old (age of a firm) or increase in size (market valuation) they undergo learning effect, which should be reflected in their efficiency. In order to empirically investigate, one needs to define the scope of the research to a specific industry and country. The main

research question of thesis is " *In the context of US biotech firms, what is the relationship between firm value efficiency and traditional financial parameters ?*"

VAIC, M/B and ROE data from 53 biotech companies was collected for 2011, 2012 and 2013. Results of linear regression analysis did not indicate any relationship between VAIC and M/B. However, it exhibited moderately positive relationship between VAIC and ROE (for year 2011 and 2012). A multilinear regression analysis between components of VAIC (HCE, SCE and CEE) and dependent variables was conducted. Here, only HCE exhibited moderately positive relationship with ROE, while M/B did not exhibit significant relationship with any of the VAIC components. Low positive correlation between ROE and VAIC was due to extreme negative data points which distorted the relationship. Hence, for future research it is important to screen the firms in detail and only include the firms that are beyond start up and development phase. In other words, include firms that have at least one product in the market. Practical relevance of this research is to leverage the knowledge of correlations discovered in this research . A software or mobile app can be designed by using the results discussed in this research to screen and shortlist equities for investment. Hence, an application/software like this can guide people without financial background to make investment decisions.

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1. Introduction

1.1 Research Background

As the world becomes technologically more complex, firms need to create new ways to increase shareholder value. Traditionally, firm value and shareholder value are attached to physical assets and future cash flows. As we move deeper into the Knowledge-based economy, value is increasingly derived from intangible assets rather than tangible assets. In 1978, Dr. Margaret Blair, reported a significant shift in the makeup of company assets. To illustrate, while in 1978, 80 percent of firm value was related to tangible asset and 20 percent was connected with intangible assets, in 1988, only 30 percent of value of firms was attributed to tangible asset, while about 70 percent was derived based on the value of their intangibles. This transfer of firm value from tangible assets towards intangible assets is consistent in industrialized countries and high tech sectors like biotechnology and pharmaceuticals.

The change from industrial, tangible asset era to high tech, intangible era has created changes in our systemic understanding of various firm performance parameters and their correlations. Previous assumptions are no longer valid in the knowledge economy. Accounting and valuation practices of fixed assets have become insufficient to help us understand real value of firm, its value generation ability and its future performance outlook.

Rise of scientific and strategic business firms have moved the focus from financial analysis to intellectual capital (IC) and value generation due to intangible assets of a firm. For instance, in 1990, the concept of intellectual value emerged when Fortune magazine published Tom Stewart's

article "Brain Power"(Stewart, 1991). This article was one of the first instances where intellectual capital and ability to generate value was first mentioned. Tom Stewart focuses on corn as commodity to demonstrate IC. Corn as a commodity in 1991 was not a high value commodity, however a creation of a disease resistant corn by Hi-pioneer was considered as a revolutionary innovation. This disease resistant corn was more valuable in comparison to normal strain of corn. This ability to create a disease resistant corn in 2 years instead of 8-10 years was attributed to a firm's IC, which is not captured or reflected on a balance sheet. Stewart further highlights the case of human managers. Good managers are valuable assets to the firm, which unfortunately can never be captured or accounted for in Securities and Exchange Commission (SEC) filings. IC expenditure can sometimes turn like oil drilling; firm can invest billions but with zero return on investment. He stresses on the need to develop a set of metrics that can help firm and investors to understand a resource management, capital return on R&D, and other various IC activities.

The tendency to overlook IC was also shown in a recent KPMG survey. In this survey, 60 percent of non-executive directors interviewed did not consider themselves to be very knowledgeable and technically skilled about non-financial performance indicators of the firm (KPMG, 2003). In addition, dotcom bubble is a well-documented evidence of what happens when investors and financial analysts lack the understanding of non-financial assets.

When knowledge is the foundation for major source of revenue and competitive advantage, it becomes increasingly important to manage and measure IC. From financial system point of view, IC is seen as a difference between market value of a firm (market capitalization) and book value of the company (as calculated on the basis of balance sheet). However, the main issue is that

intellectual capital is neglected in accounting systems and it is rarely reflected in the reporting and accounting practices.

Traditionally, intangible assets like patents and trademarks are valued and monetized. However, process innovations, business innovations, human resource management are rarely understood by outsiders and monetized**.** Valuation of IC depends on a number of underlying assumptions and its ability to add value to the firm in terms of future cash flows or competitive advantage. For example, a new patent is useful to the firm only if it can be leveraged to increase its profits (cash flow) or gain competitive advantage. Hence, valuation of this patent depends on future economic outlook, assessment of firm owning the patent, marketing strategy to leverage IC etc. In addition, other IC components like human capital and customer relationships are very difficult to assess in terms of their monetary value. In practice, investment management firms rarely examine a firm's internal processes and hardly perform comparative analysis of similar firms. Investment firms predominantly monitor the financial health of a firm through the firm's financial statements. As a result, most of them overlook IC or accept the IC valuation that is provided by the firm. Although many of these intangible assets cannot be monetized, they need to be recognized when evaluating a firm. In sum, existing problem of IC is the methodology of its valuation.

One way to measure IC is by VAIC method developed by A.Pulic (Pulic,1999). VAIC method looks at the value generation ability of intellectual capital of a firm. Since VAIC method was published recently, researchers (refer to literature review) have tried to understand and validate this methodology. One way researchers have tried to assess and validate VAIC is by empirically investigating correlation between VAIC and traditional financial parameters. This research thesis will address shortcoming from previous VAIC research work and extend understanding of VAIC

method as an firm efficiency. VAIC method can be termed as an IC accounting method that attempts to calculate how efficient a firm has been in its utilization of resources like capital, human capital, etc. At a macro level, firm has three types of resources that can be leveraged to generate value. These three resources are capital, human capital and structural capital. Capital is seen in terms of financial and physical assets of a firm. Efficiency of its capital utilization is termed as capital employed efficiency (CEE). Human capital consist of the workers employed. Efficiency of human capital utilization is termed as human capital efficiency (HCE). Structural capital consists of various intangibles like business process, organizational structures, documentation practices etc. Efficiency of structural capital is termed as structural capital efficiency (SCE).

This thesis aims at understanding the relationship between a firm's value generation ability (VAIC) and traditional financial parameters which will be explained in the subsequent sections.

1.2 Research Objective

Since the VAIC method was introduced, researchers (Maditinos, et al, 2011; Pew et al, 2007; Chen,et al 2005) have tried to validate the methodology by studying correlation of VAIC with existing traditional firm efficiency parameters like Market to Book ratio (M/B ratio), Return on Asset (ROA) and Return on Equity (ROE). This has been done mainly to understand the relevance of VAIC and see if firm efficiency is reflected in financial markets. In a case of acceptance of alternative hypothesis, this research will validate that for a defined industry and country, higher efficiency of a firm is reflected in the profit making ability of a firm (higher ROE). Few empirical studies (Maditinos, et al, 2011; Pew et al, 2007; Chen,et al 2005) have

been undertaken by researchers in past to study correlation between intellectual capital and traditional financial parameters. These studies have looked at companies listed in different stock exchanges in different countries. However, no consensus has been reached if VAIC has a direct correlation with traditional financial parameters (Stahle et al, 2011). An interesting insight was provided by Stahle et al (2011), VAIC varies considerably between different industrial sectors and countries in which these sectors exist. According to Stahle and colleagues (Stahle et al, 2011), VAIC needs to be assessed according to industry sectors. Stahle argues that each industrial sector has different value generation ability / overall efficiency of converting raw material to final product or service. For example, value efficiency of mining industry (labour intensive industry) cannot be compared to IT or consultancy industry.

The thesis builds on this idea to assess VAIC in one industry sector i.e. biotechnology / pharmaceutical. The objective of this study is to understand relationship between firm value efficiency (VAIC) of biotechnology firms listed in NASDAQ biotech index between year 2011 and 2013 and traditional efficiency financial parameters of M/B and ROE**.** Biotech industry is selected as a sample for this study due to two reasons. Firstly, it is one of the industries that require continuous investment in R&D, and other value added operations to stay in business. It is a knowledge based industry that require new product and process development to survive and grow. Secondly, it is an industry which is closely regulated; hence, products and services are thoroughly audited. Production processes and new products are audited by Food and Drug Administration (FDA). Hence, no biotech / pharmaceutical firm can provide sub standard products or outsource it to a third world country. Hence, an effective comparison regarding a firm's efficiency can be made between various firms.

Investigation of these relationships can provide better understanding of role of IC, fill in the knowledge gap and confirm previous studies. In addition, a VAIC database can provide insights in efficiency of various firms in same industrial sector.

1.3 Research Question

In this thesis, investors are the main stakeholders in the process. Therefore, variable selection has been done accordingly. Two main measures that concern investors are ROE and M/B ratio. ROE is defined as the ratio of net income to total equity (asset minus liabilities). A normal investor can only own equity as a direct security. Hence, ROE measure is very important in decision making process for security selection. The second measure M/B ratio, indicates how market views a particular security. For example, company with high growth potential has a high demand for its equity. Due to this high demand its stock price goes up, which leads to increase in market value (market value = stock price * shares outstanding). Increase in market value in turn leads to increase in M/B ratio. M/B ratio gives an overview of market's outlook on a particular security.

Main Research Question

In the context of US biotech firms, what is the relationship between firm value efficiency and traditional financial parameters ?

The main research question was selected to understand whether the traditional financial parameters reflect efficiency of a firm. The logic behind this reasoning can be understood in a very straight forward manner. For example, consider two firms, an efficient firm which utilizes

less resources to generate higher revenue in comparison to a less efficient firm that may utilize more resource to generate same output. Assuming all financial statements are audited before release and no other information asymmetry exist in the market. An efficient firm is likely to have higher market value (M/B) and return on equity (ROE) in comparison to a less efficient firm. In reality, this relationship seems true in theory. However, needs to be proved by doing extensive data analysis.

Sub questions

1. What is value efficiency of a firm and why is it important to measure it ?
2. What are the components of firm value efficiency that contribute towards calculation of VAIC ?
3. Is VAIC calculation and methodology based on accounting principles ?

   (VAIC is calculated through a firm's accounting data, therefore this question looks into accounting principles and checks whether VAIC calculation is in accordance with accounting rules)
4. What is the current state of research on VAIC methodology for calculation of firm value efficiency ?

   (This question will be answered through literature review and finding regarding what the existing state of research on VAIC is)
5. What is the relationship between VAIC components and traditional financial parameters. What does it signify in biotechnology industry ?
6. Does the relationship between VAIC and traditional financial parameters improve under the influence of moderating variables ? (for example : size of firm, IPO launch etc)

The first four sub questions will be addressed through an extensive literature review. These questions are designed to understand concept of firm value efficiency, what the underlying assumptions are what they signify. Sub-questions 5 and 6 will be addressed through variable selection, data collection, operationalization of variables, and developing a multi linear regression model. All these questions, in turn, will help to answer the main research question.

1.4 Contribution of the Study

1.4.1 Academic Relevance

This thesis serves as a confirmatory study to previously mentioned studies (in research objective) as well as expands the understanding of firm efficiency relationship with traditional financial parameters for biotechnology industry. As mentioned earlier, this thesis focuses on a specific technology sector, rather than the whole stock exchange. This restriction in scope, by focusing on a specific technology sector also addresses criticism by Stahle et al (2011) and will validate it. In addition, this thesis will help in filling in a knowledge gap and extend the understanding of VAIC with respect to biotechnology industry. It will also help in understanding of which activities in biotechnology industry are the most efficient with respect to value addition and which activities are least efficient.

In this thesis, I also propose a change in HCE calculation method (Chapter 3). Therefore, this study also looks into a new way of calculating human capital efficiency. According to existing VAIC method, all wages are to be considered for HCE calculation purpose. However, in knowledge economy, workers can be divided into classes namely normal and value addition workers (Becker & Murphy, 1992). Therefore, worker can be divided into 2 categories: Normal

workers wages (wages to workers that are directly associated with manufacturing) and value addition workers wages (workers associated value added activities). Wages to normal workers is associated with manufacturing and is considered as part of cost of sales in income statement. Value addition workers wages are not directly associated with manufacturing, but help in improving product or service. This gives strategic edge to the firm. For HCE calculation, wages of only value addition workers will be considered.

1.4.2 Managerial Relevance

This thesis will have managerial relevance in biotechnology industry and investment management. For a pharmaceutical or biotechnology firm, by understanding efficiency terms and comparing them with their competitors can help them to understand where their inefficiencies exist. For example, a lower HCE with respect to their competitors can help mangers to understand more about their employees and make decisions accordingly.

VAIC data can also help managers in investment firm to make a decision for security/stock selection and portfolio generation. I have interacted with few analysts from investment firms. The current organizational structure is very individualistic in nature, i.e. each analyst works independently in assessing few firms. Creation of VAIC database can be utilized an screening tool for security selection. This database can lead to change in organizational setup. Instead of an analyst working in isolation, more team based approach can be adopted in which information flows from one analyst to another (similar to assembly line in car manufacturing). Managers can setup their team so that raw data is screened through VAIC and assessed more thoroughly.

1.4.3 Relevance with MoT Program

This research thesis is one on the first attempt in MoT program in TU delft to connect traditional financial parameters and ratios with a firm's value generation ability. Most thesis in TU Delft library repository discuss about valuation of intangible firm assets like patents and their contribution to profitability of a firm (Zand, 2011; . On the contrary, this thesis takes a different approach to intangible assets. The concepts discussed in this thesis look beyond normal profitability and bottom line of income statements. Instead, it looks at value generation ability. In theory, a firm with higher value generation ability has higher probability for growth.

Relevance of this research is in line with MoT research. This research thesis attempts to understand firm efficiency for high tech industrial sector. In this research thesis, I have focused on biotech sector in US, but it can easily be applied to other high tech sectors like software development industry, automation industry etc. Researchers that utilize this concept of firm value efficiency to measure firm efficiency can understand how are different resources utilized in different industrial sector. This understanding of efficiency can help MoT students and managers to understand which are value rich areas in a firm and which areas in a firm require more attention. This can also lead to better understanding of how implementation of various technologies in a firm will affect bottom line and value generation.

1.5 Research Framework

In this section, I will explain the schematic of the research framework. This research is quantitative in nature. The foundation of the research is based on VAIC theory, which proposes and explains calculation of value generation from balance sheet data. The other theory which

serves as the foundation for this research is efficient market hypothesis (Yaes, 1989). According to this theory, financial parameters (price) reflect fair value of the firm. Data will collected from annual reports of the firm. Dependent data will be collected directly, while independent data will be calculated based on Pulic's VAIC methodology. Depending on literature research, probable moderating or mediating variables will be identified. Next stage will be hypothesis formulation based on literature review and variable identification. In case of identification of moderating or mediating variable, relevant data will be collected. Regression analysis will be utilized to understand correlations between dependent, independent and moderating variable. The results from regression analysis will be summarized in result and analysis section. Later on, significance of these results will be understood in the context of biotechnology and pharmaceutical industry.

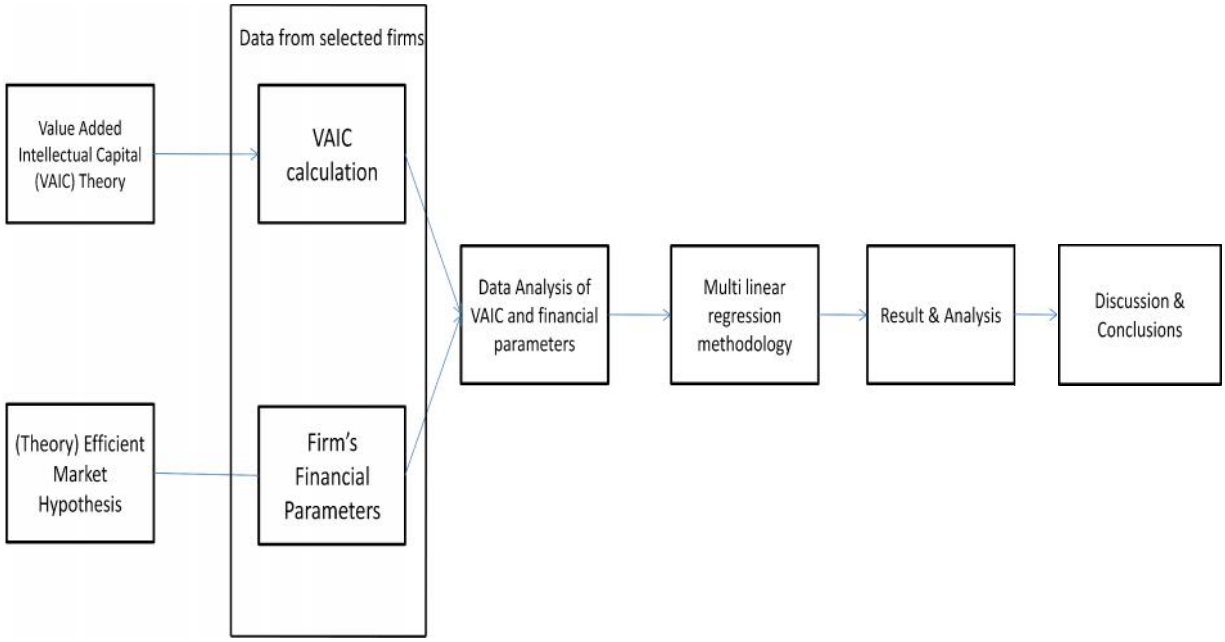

Figure 1: Research Framework

2. Literature Review

Literature review is divided into 2 sections. Section 2.1 will discuss the efficiency market hypothesis(EMH) and VAIC methodology. EMH forms the foundation for dependent variables, while VAIC methodology explains selection of independent variables. Section 2.2 will discuss studies done using VAIC methodology and their results. This section will help to understand work done in the field of firm value efficiency.

2.1 Theories and IC Valuation Method

2.1.1 VAIC Method

Firm value efficiency is still a new concept in management and financial research (as the concept and methodology was first proposed in 1999). Firm value efficiency provides a new dimension in understanding of utilization of resources by a company. By comparing firm value efficiency of two similar companies, investors and shareholders can understand how efficient the management of a company has been in its decision making and resource utilization. Moreover, firm efficiency can be utilized by management of a firm during mergers and acquisition. Management of a company can look into firm value efficiency data before a potential acquisition to understand inner workings. This also helps to understand where are the short comings in terms of efficiency for a firm, and provide information for potential improvement after merger or acquisition.

Any firm across the globe has three main type of resources available to them, namely human resource, capital resource (Cash, Plant, Equipment etc) and structural resource(organizational

setup, knowledge etc). By utilizing these resources, a firm can create value by selling products and services (Bontis, 1998).

VAIC stands for Value added intellectual coefficient. This method was first proposed by Ante Pulic in 1999. The main idea of his proposal was to understand value efficiency of IC of knowledge based organizations rather than carry out value estimation of IC. The main difference between the traditional concept of IC valuation and Pulic's value efficiency is that traditional valuation method tries to find a market price of an intangible commodity. While Pulic's VAIC method looks at firm level to see how efficient they are in value creation. VAIC measurement approach differs significantly from traditional measurement approach, which was rooted more in the value of physical asset and material. Hence, net income or profitability (ROE, ROA etc) of a firm was calculated based on cost (buying raw materials at low price and selling finished good at high price). VAIC measure looks at the value addition and performance of intellectual capital. This value creation is a direct result of investment and management of various IC employed by firm.

As per Pulic, it is necessary to identify a methodology that allows the measurement of "intellectual work efficiency similar to what Taylor did with physical work" (Pulic, 2008, p.3). During industrial revolution, science and knowledge were main factors that led to improvement in human productivity, and firm profits. In current scenario, it is very difficult to measure intellectual work efficiency. For example, how do we measure productivity of a scientist or R&D unit of an organization? VAIC method is a step towards this direction.

Pulic used Skandia Navigator as basis to build his methodology. Skandia Navigator was one of the first methods to calculate and visualize the value of intangible capital. Skandia approach is based on the notion that IC represents the difference between market and book value of a company (Edvinsson and Malone, 1997). However, Skandia approach was more in line of measuring IC and not value created by IC and its efficiency.

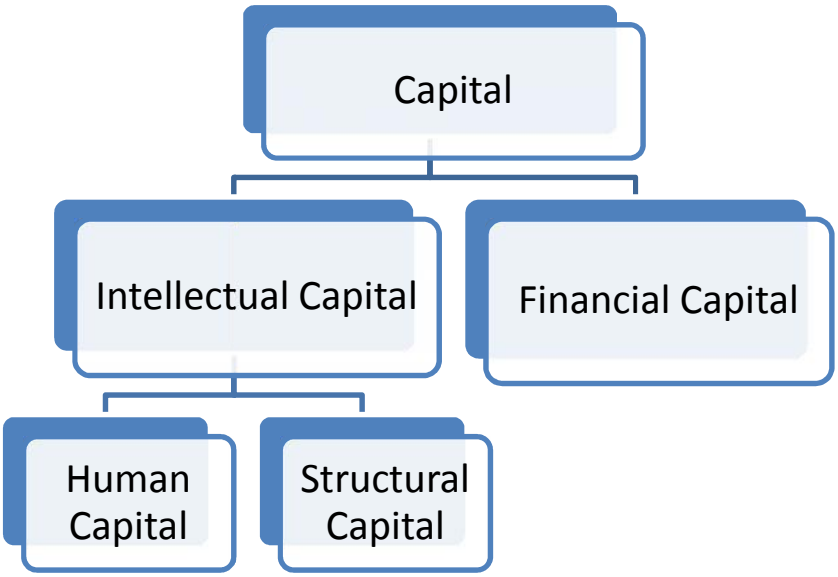

Figure 2: Classification of capital (Edvinsson and Malone, 1997)

Pulic in his VAIC method uses the term IC as not collection of different assets, but a set of knowledge workers. He states that “intellectual capital is used as a synonym for those employees, who have the capability of transforming and incorporating knowledge into product and service that create value" (Pulic, 2008, p.5). Cost of knowledge workers is considered as an investment. Human Capital (HC) as from figure 2 refers to all characteristics that define skills, abilities, competencies of employees, while Structural Capital (SC) covers all characteristics of

intangible assets like brands, patents, process etc. In order to understand efficiency, HC is considered as an investment in knowledge workers (wages and salaries to workers).

A firm utilizes its financial capital, human capital and structural capital to convert raw data or material into products and services. Here, firm value efficiency can be defined as value added (VA) as value created per time unit by utilization of firm's resources. VAIC as a measure of firm's efficiency is made of three efficiency terms. These terms are

Capital Employed Efficiency (CEE): Efficiency of capital employed

Human Capital Efficiency (HCE): Efficiency of human capital

Structural Capital efficiency (SCE): Efficiency of structural capital

Summation of all three terms gives us VAIC

VAIC = CEE + HCE + SCE

2.1.2 Efficient Market Hypothesis (EMH)

As mentioned in Chapter 1.3 , two selected dependent variables selected are M/B ratio and ROE. These variables are derived from financial balance sheet data of a firm and understanding of efficiency market hypothesis. Efficient market hypothesis states that current stock prices fully reflect available information about the value of the firm. Hence, a stock price of a firm incorporates a fair value of the firm. This fair value includes assets, future cash flows, brand recognition etc. Hence, in an ideal world EMH should encompass firm value efficiency and

should be reflected in various derived financial parameters like ROE and M/B ratio (Clark, Jandik, & Mandelker, 2001).

The key reason for existence of efficient market is the intense competition among investors to profit from new information. Due to this intense competition, market is at equilibrium and prices reflect complete information of a firm including ROE and M/B. However, there are three different kinds of information that influence security prices. Financial research distinguishes between three different versions of EMH depending on type of "information" available. These are i) Weak form efficiency ii) Semi strong form efficiency iii) Strong form efficiency.

i) Weak form: Weak form of efficient market hypothesis posit that current price fully incorporates information contained in past prices only. This means that the fair price of a security is captured by past prices and hence investor cannot take advantage by studying past prices.

ii) Semi strong form : Semi strong form hypothesis postulates that current prices capture all publicly available information. This includes not only past prices, but also data reported in company's financial statement. Public information may also include current state of R&D plans or other acquisition plans. This form of EMH will be utilized for this research. As it most closely represents real life information asymmetry.

iii) Strong form : Strong form of EMH postulates that current prices capture all public and private information. This means that a firm's management (insiders) are also not able to take advantage of information available.

2.2 IC & VAIC Studies

Scholars have attempted to define Intellectual Capital (IC) since 1990s (Brooking, 1996; DATI 1998, 1999; Petty and Guthrie, 1999; Svieby, 1998). The term intellectual capital has been frequently used without clear definition. Organization for Economic Co-operation and Development (OECD) defines IC as "economic value of two categories of intangible assets" : Organization ("Structural") Capital and Human Capital. Structural capital refers to things like distribution network, intellectual property, supply chain, raw material sourcing etc. Human capital refers to human resources and employee quality within the organization and external human resources like customers and suppliers. An obstacle related to this increased complexity of classification is that GAAP or normal accounting practices do not capture these. The identification and measurement of these assets is absent from balance sheet, income statement and cash flow statement.

Historical progress of IC can be broadly divided into 2 stages. First stage deals with intellectual capital framework and is focused on awareness raising activity that emphasized on how to communicate the importance of identifying, measuring and understanding the potential for intellectual capital. First stage was to stress on the invisible and make it visible. The second stage of development of intellectual capital framework is to establish research, study measurement parameters and its effect on various financial and market performance parameters (Petty & Guthrie, 2000).

Historically, researchers and firms have attempted to measure intellectual capital. In 1964, first attempts were made to measure human resources in financial terms. This concept was known as

human resource accounting (HRA). The objective of HRA is to “measure the economic and financial value of people to the organization” (Sackmann et al, 1989) this provides input for strategic decision making. Sackmann (Sackmann et al, 1989) have proposed three types of HRA measurement models: cost models, HR value models and monetary emphasis models.

In 1996, Kaplan and Norton, formulated balance scorecard (BSC) developed a multi dimensional system to guide strategic decision making. This measurement technique forced organizations to measure financial and non-financial assets including customer capital, internal business processes, learning perspective and growth perspective (Bontis et al, 1999)

One of the earliest attempts to identify and measure IC was attempted by Skandia Navigator (Brennan & Connell, 2000). Skandia (swedish financial firm) appointed Lev Edvinsson as director of intellectual capital. Edvinsson developed a model known as Navigator for IC reporting. This model consisted of 2 parts: human capital and structural capital. Skandia's navigator model looked into both financial and non-financial value assets in order to conduct market valuation of firm. Skandia's navigator tool has been used by many firms to value their R&D and process innovation. However, skandia's model relied heavily on balance sheet for monetization. In addition, this model recommended about 100 indices to measure IC. Hence, measurement using a rubric with 100 parameters is nearly impossible.

Pulic (Pulic, 2000) in 2000s developed VAIC (Value Added Intellectual Co-efficient) to quantify tangible (Capital) and intangible assets (Human and Structural). VAIC method indirectly measure IC. However, Pulic defined the term IC as not value of intangible assets, but more in terms of efficiency or value addition by three types of inputs: physical and financial capital,

human capital and structural capital, namely Capital Employed Efficiency (CEE), Human Capital Efficiency (HCE) and Structural Capital Efficiency (SCE). Sum of all three measures is defined as the value of VAIC. Higher the VAIC, better is the management of resources by a firm. Pulic in 2000, randomly selected 30 companies from FTSE 250 from 1992 to 1998. He found correlation between market value of a firm and VAIC.

Frier and Williams (Frier et al, 2003) used data from 75 publicly listed firms in South Africa and adopted VAIC method to assess the relationship between intellectual capital and traditional measures of efficiency like ROA, turnover of total assets, and market to book value ratio. These 75 publicly listed firms were selected from one of the four sector i) banking ii) electrical iii) information technology iv) services. In this study, empirical findings fail to find any strong association between the VAIC and traditional measures of efficiency. They provided many explanations, like lack of variation between dependent and independent variables, overall lack of association may have resulted from the concepts of value addition and profitability (like ROA and asset turnover). Various moderating factors like size of the firm, leverage, financial performance and industry type provided little explanation from a multi linear regression analysis.

Ming-Chin Chen, Shu-Ju Cheng and Yuhchang Hwang (Chen et al, 2005) studied 4254 firms from Taiwan stock exchange from 1992-2002 using VAIC method. These selected firms were divided into 20 industries. In addition to three independent variables of HCE, SCE and CEE they also investigated R&D expense and advertising expense (AD). Their study resulted in three models. Model 1 described relationship of dependent variable with VAIC. Model 2 described relationship of dependent variable with HCE, SCE and CEE (components of VAIC). While model 2 described relationship with 5 independent variables (HCE, SCE, CEE, R&D and AD).

Their results indicated that VAIC, CEE (capital efficiency), HCE (human capital efficiency) and R&D expense are positively related to M/B ratio. Adjusted R^2 for relationship between independent variables and M/B (as dependent variable) was 0.1077, while in model 2 for the same relationship, adjusted R^2 increased to 0.2515. In model 3, adjusted R^2 further increased to 0.2916, suggesting investors may value different components differently. In addition, they also investigated four financial performance variables (dependent), namely, return on equity (ROE), return on asset (ROA), growth revenue (GR) and employee productivity (EP). All the four financial performance variables were positively correlated to VAIC and CEE.

Researchers in Greece (Maditinos et al, 2011) also developed a regression model of 96 companies listed in Athens Stock Exchange (ASE). These companies were further classified into four economic sectors, namely i) construction and materials ii) industrial goods and services iii) food and beverage iv) personal and household goods. Data from 2006 to 2008 was analyzed. Results from this study failed to support significant relationship between market valuation of a firm and VAIC, HCE, SCE and CEE. No significant correlation was observed between financial performance (ROA, ROE and GR) variables and independent variables of SCE and CEE. Significant positive relationship was observed between HCE and ROE.

While researchers in Australia (Pew Tan et al, 2007), studied 150 firms listed in Singapore stock exchange. Here the industries were classified into 4 industrial groups namely, i) manufacturing related ii) trading related iii) Services related iv) Property related. Purpose of this study was to check IC efficiency's correlation to firm's performance parameters.(ROE, annual stock return (ASR) and earnings per share (EPS)). These parameters were assigned as dependent variables. In addition, this study explored firm efficiency as a future prediction tool for firm's performance.

For all three dependent variables VAIC had a significant positive correlation with all three firm performance parameters. Firm efficiency as firm performance was also modestly correlated with future growth of the company. This was studied by calculating VAIC for year x and testing it against companies performance for year x+1.For this, firm value efficiency (VAIC) for year 2000 was able to explain only about 9 percent of growth in year 2001. Similarly, VAIC of year 2001 was able to explain 12 percent of growth in year 2002.

Stahle et al, strongly criticized Pulic's VAIC methodology in 2011. In their analysis, they criticized the methodology for calculation of SCE as operating margin. Which is correct from accounting point of view. However, a company in the free market is able to have high operating margin only if it has, a patent to protect its product or has a good branding and good customer relationship. Hence, operating margin of a firm is causally tied to decisions made by management of a company. In 2013, Iazzolino et al, published another critical review on VAIC which refuted the claims made by Stahle et al.

In 2013, G.Iazzolino and D.Laise, published a critical review of the VAIC methodology. This paper looked at the VAIC methodology from accounting theories. In this paper, they theoretically verified that VAIC calculation is in sync with existing accounting theories and does not violate any accounting principles. They interpreted all the terms used by Pulic in his paper, as many terms were wrongly interpreted by critics. In addition, they also addressed criticism by Stahle et al and justified the calculus of VAIC (as shown below)

VA = HC + SC

The above equation describes that the value generation can only occur through human capital and structural capital.

- 1=(HC/VA) + (SC/VA)
- 1=[1/ (VA/HC)] + SC/VA

This is

SCE =1- [1/(HCE)]

This equation suggest, if HCE < 1, value addition (VA) is unable to sustain value creation activities like R&D and general administrative activities like marketing, sales, human resources etc. Hence, there is a value destruction. If HCE = 1, value addition is enough to sustain value creation activities. Only when HCE > 1, value addition will be able to sustain firm's value creation activities.

Few authors (Chizari et al, 2016 and Biyun et al, 2015) have researched VAIC for pharmaceutical companies in Iran and China. Chizari et al, investigated pharmaceutical companies listed in Tehran stock exchange. Relationship between M/B and VAIC (and its components) as well as Tobin Q and VAIC (and its components) was evaluated (Chizari et al, 2016). HCE and SCE were found to have significant relationship with 95% and 99% confidence respectively. However, one of the short coming of this study was sample size. Their sample size comprised of only 25 companies. In addition, Iranian pharmaceutical and biotechnology companies are not at the fore front of drug discovery and innovation. These companies generally carry out technology transfer from western firms for known drugs and focus on manufacturing.

Hence, this study cannot be seen in the context of knowledge management and generalized for understanding of value efficiency of pharmaceutical companies.

Biyun Lv et al (Biyun et al, 2015) , investigated value efficiency for multinational biopharmaceutical companies in Chinese market. They investigated 81 companies operating in Chinese market. However, their methodology deviated from Pulic's VAIC methodology. Apart from HCE, SCE and CEE, this paper also constructed more independent variables like relational customer efficiency (RCE). Despite the fact that Pulic defined SCE as all activities of a firm that do not encompass human resource and physical capital, but contribute to value addition. They calculated SCE as VA / SC, instead of SC / VA and VAIC was a summation of HCE, SCE and RCE (relational capital efficiency). They failed to justify their way of calculation, hence it is difficult to accept their results.

Author	Country	Sectors	Independent Variables	Dependent Variables	Results (significant relationships only)
Frier et al, 2003	South Africa	i) Banking ii) Electrical iii) Information technology iv) Services	VAIC, HCE, SCE and CEE	i) Return on Asset (ROA) ii) Asset turnover (ATO) iii) Market to Book Ratio (M/B)	i) CEE (-)ATO ii) CEE (+) MB iii) HCE (-) ATO
Chen et al, 2005	Taiwan	20 industrial sectors.	VAIC, HCE, SCE , CEE, R&D and Advertising (AD)	i)M/B ratio ii) ROA iii) GR (Growth in revenue) iv) Employee productivity (EP) v) ROE	i) VAIC (+) M/B ii) CEE (+) M/B iii) HCE (+) M/B iv) M/B (+)R&D v) VAIC (+) ROE, ROA, GR and EP vi) CEE (+) ROE, ROA, GR and EP
Maditinos et al, 2011	Greece	i) Construction and Materials ii) Industrial goods and services iii) Food and beverage iv) Personal and Household Goods	VAIC, HCE, SCE and CEE	i) M/B Ratio ii) ROE iii) ROA iv) GR	i) HCE (+) ROE
Pew Tan et al, 2007	Singapore	10 industrial sectors grouped into 4. i) Manufacturing related ii) Trading related iii) Services related iv) Property related	VAIC, HCE, SCE and CEE	i) ROE ii) Earnings per share (EPS) iii) Annual stock returns (ASR)	i) VAIC (+) ROE, EPS and ASR ii) VAIC (xth year) (+) ROE, EPS and ASR (x+1 year)
Muhammad et al, 2009	Malaysia	Financial sector	VAIC, HCE, SCE and CEE	None	Intra sectorial comparison. For example, public vs private; insurance vs brokerage etc
Okzan et al, 2016	Turkey	Banking Sector	VAIC, HCE,SCE ,CEE, Total Assets, Leverage, Deposits	i) ROA	i) VAIC (+) ROA i) CEE (+) ROA

Table 1: Summary of VAIC studies

The above table summarizes major VAIC studies. It is quite evident from these studies that no academic consensus exist. Instead, VAIC relationship with various traditional financial parameters exist in certain countries and certain industries only. For example, countries with high tech and knowledge based industries like Singapore and Taiwan exhibited positive correlation between VAIC and traditional financial parameters. Developing countries like South Africa and Turkey did not show correlation between VAIC and traditional financial parameters. However ,in developing countries positive relationship between HCE and traditional financial parameters exist**.**

Most papers (discussed above) that have been published evaluate VAIC in developing countries and across industries. This may be due to difference in the financial reporting standards between Hence, in my opinion, researchers need to develop a better sampling strategy and study each individual industry separately. Before doing a VAIC research, it is important to understand which industries are knowledge intensive. This can be done by understanding of their R&D expenses as well as marketing and sales expense as a percentage of revenue or operating income. Secondly, it is also important to understand which countries promote knowledge industries through laws and funding. Based on the above two points, researchers can investigate a specific industrial sector in specific country / region. This sampling strategy will help in developing a better understanding of firm value efficiency and give deeper insights into working of each industrial sector in a specific region. This data can be collected and utilized to re evaluate specific national policies and funding programs. For example, low human capital efficiency in country A (in comparison to global average) for software development may prompt the country to build more universities or change educational structure.

In conclusion, literature review above addresses first four research sub questions from section 1.3.

Sub Question	Answer
1. What is value efficiency of a firm and why is it important to measure it ?	Firm value efficiency can be defined as value added or value created per unit time by utilization of firm's resources. Knowledge of firm efficiency can utilized to identify in efficient areas in a firm or compare their own efficiency with that of competitor to improve profits.
2. What are the components of firm value efficiency that contribute towards calculation of VAIC ?	According to Pulic (Pulic, 1999), firm value efficiency has three main components namely capital employed efficiency (CEE), human capital efficiency (HCE) and structural capital efficiency (SCE). CEE looks at the value created by total assets of a firm. HCE looks at value creation by human capital expenditure and SCE looks at value creation through structural capital.

3. Is VAIC calculation and methodology based on accounting principles ?	According to G.Iazzolino and D.Laise, (Iazzolino et al, 2013) firm value efficiency calculation do not violate accounting principles
4. What is the current state of research on VAIC methodology for calculation of firm value efficiency ?	Currently, (see table 1), there is no academic consensus whether firm efficiency correlates with traditional financial parameters. However, in developed economies like taiwan and singapore empirical data suggest that VAIC is related with firm's financial parameters, while this relationship has not been observed in developing countries like South Africa, Greece and Turkey.

Table 2: Summary of Research Questions

3. Conceptual Framework and Research Methodology

3.1 Conceptual Framework

This thesis introduces a conceptual framework, the reflects on literature review discussed in chapter two. It uses Pulic's VAIC methodology to investigate relationship between firm value efficiency (VAIC) and traditional financial performance parameters (M/B and ROE).

3.1.1 VAIC and Market to Book ratio

Firm value efficiency as measured by VAIC, reflects on efficiency of resource utilization. Hence, firms that are able to optimize resource utilization in an efficient manner have higher probability of increasing their net profit. This increase in net profit leads to increase in market valuation of the firm, investor confidence and increase in share price. This ultimately leads to increase in market value and M/B ratio. In other words, market estimates value of companies having greater efficiency to be significantly greater than book value. In theory, this sequence of reasoning seems very probable, but it has not been experimentally proved. It can by hypothesized that higher VAIC leads to higher market to book ratio.

H1 : Firms with greater VAIC have higher M/B ratio.

H1a : Firms with greater human capital efficiency (HCE) have higher M/B ratio.

H1b : Firms with greater structural capital efficiency (HCE) have higher M/B ratio.

H1c : Firms with greater capital employed efficiency (CEE) have higher M/B ratio.

3.1.2 VAIC and Return on Equity (ROE)

As mentioned in the introduction chapter, return on equity is defined as ratio of net income by equity (asset minus liabilities). Theoretically, in a knowledge industry like biotechnology / pharmaceutical, an optimized resource utilization leads to higher production quantity, less waste, and better quality. A good quality product in turn attracts more revenue, which leads to increase in net income. This increase in net income is reflected in their return on equity ratio. Hence, a firm that has a higher net profit can finance itself leading to decrease in liability and increase in asset, which in turn increases ROE. As discussed in literature review, Frier and William (Frier et al, 2003) analyzed the relationship between VAIC and traditional financial parameters like ROA and ROE. However, they failed to find any significant relationship. While Chen et al, found significant relationship between VAIC and ROE for companies in Taiwan. In this thesis, I hypothesize :

H2 : Firms with higher VAIC have higher ROE

H2a : Firms with higher HCE have higher ROE

H2b : Firms with higher SCE have higher ROE

H2c : Firms with higher CEE have higher ROE

3.1.3 Effect of Moderating Variables

In statistics, moderation happens when relationship between independent and dependent variable depends on a third variable. This third variable is known as moderating variable.

According to Theodare Paul Wright (Wright, 1936), production cost is dependent on a firm's learning curve. His study theorized that as firm grow in size and stay in business for long time, they undergo learning curve. This learning effect theory can be theorized for biotechnology and pharmaceutical industries. As biotechnology firms age or grow in size, it's management learns from experience. This experience leads to better decision making in its utilization of human and capital resource as well as contributes to structural processes of the firm. Hence, in this thesis I will investigate effect of two moderating variables, namely Firm Size (market value) and Age of Firm (IPO launch date). Probable result expected in these hypothesis is that older firms (greater in age) can be expected to have better correlation between independent and dependent variables in comparison to young or recently established firms. Similar argumentation can be made for large firms in comparison to small firms.

H3a: Age of a firm (M) moderates relationship between VAIC and M/B ratio

H3b: Size of a firm (M) moderates relationship between VAIC and M/B ratio

H4a: Age of a firm (M) moderates relationship between VAIC and ROE

H4b: Size of a firm (M) moderates relationship between VAIC and ROE

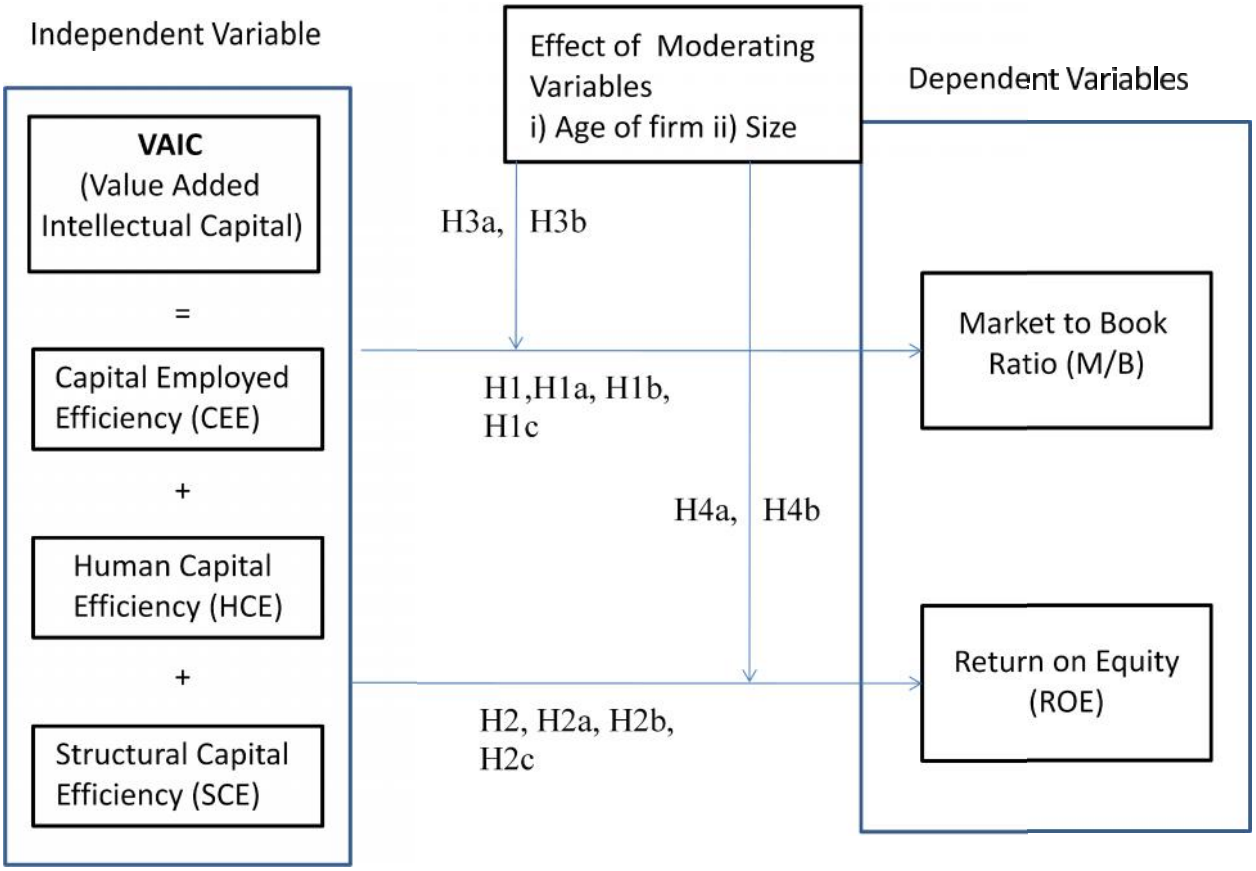

Figure 3: Conceptual framework of the thesis

3.2 Sampling and Data Collection

For this research thesis, strategic sampling will be carried out. The population data set is NASDAQ biotech index. This index consist of 190 companies. Companies in this index have to fulfill certain requirements before they can be listed. These requirements are that the security must be exclusively listed on NASDAQ (unless it was listed on two indexes before 2004). The issuer of the security must be classified as according to the industry classification benchmark as either Biotechnology or Pharmaceuticals, the security may not be issued by a company

undergoing bankruptcy proceedings. The security must have a minimum market capitalization of at least $200 million. The security must have an average daily trading volume of at least 100,000 shares. The issuer of the security must have "seasoned" on NASDAQ or another re cognized market for at least 6 months.

Sampling will be done on the companies that were listed on NASDAQ index from the period of 2011 to 2013. The selection of time period from 2011 to 2013 is due to the fact that this period saw minimum external economic fluctuations. Each year will be evaluated separately. This is mainly to minimize macro economic and regulatory factors that change from year to year. After the financial crisis of 2008-09, this period was a recovery period and major economic decisions like interest rate change or major policy change did not take place. Hence this time period is an appropriate time period to study correlation between firm value efficiency (VAIC) and traditional financial parameters (ROE and M/B). Preliminary observation revealed that 190 companies are listed. Out of 190, 91 companies were listed during the time period of 2011 to 2013. Hence, the sub population consist of 91 firms. These 91 firms were screened to understand their balance sheet, income statement and history. Based on this initial screening, it was found that some companies had missing data on their books, while companies had filed few quarterly report but no annual report. In addition, many companies had negative book value. This indicates that the firm is theoretically bankrupt. Some firms had a consistent negative operating income and financial ratios. On closer investigation, these firms were part of a large firm. These firms were able to survive due to the financial support of large firms. From 91 companies, the companies that had above mentioned conditions were not included for further analysis. A total of 53 companies were selected for in depth data collection and further calculations.

3.3 Operationalization of Variables

According to Pulic's methodology for VAIC calculations, forms the basis of variable selection. VAIC is an analytical procedure designed to effectively monitor , understand and evaluate efficiency of a firm. The goal of VAIC methodology is to create a efficiency measuring model that will indicate value creation and productivity of a firm. For any firm, value creation process happens by utilization of resources. This value creation process occurs by conversion of raw material into products or service, which are then sold in market to generate revenue. Resources employed in value creation process can be broadly categorized into two : Human resources and structural resources.

Human capital of a company is its workforce. According to accounting principle, it is considered as a cost to the company. However, according to Pulic's VAIC methodology, human capital is considered as an investment. The logic behind this is very straight forward. In knowledge and high tech industries, employees invest their knowledge and abilities in the firm to create better products and services. These products and services eventually lead to revenue generation and value creation. Hence, one of the resource that needs to be considered as variable in calculation of firm efficiency is expenditure on human capital. In this thesis, I don't use the pulic's definition of human capital in strict sense. In a knowledge industry, workers can be divided into two broad categories high ("Competencies for the knowledge economy", 2016) high skilled worker and other worker. In pharmaceutical industry, there are 4 main work sectors in which workers are employed namely research and development, production, administration, and sales. Out of these 4 division, R&D, administration and sales require high skilled workers (in general), while

production sector employees low skilled workers (in general).For this research thesis, I have divided worker population into two broad categories, High skilled human capital and Low skilled human capital. Low skilled human capital refers to workers employed directly in manufacturing / production process. These workers are employed on the manufacturing floor and quality department. They deal with day to day operations of production and ensure product meets FDA guidelines. These workers can be considered analogous to workers employed in a assembly line in an automotive industry. Hence, these workers are considered as cost to the company. Wages and salaries to these workers will not be considered in VAIC calculation. High skilled human capital in pharmaceutical and biotechnology is composed of R&D and Marketing / Sales department. These departments ensure that the firm has enough products in its pipelines which will ensure value creation in future. R&D department normally serves dual function in a pharmaceutical industry. One function is to research new drug molecules, undertake clinical trials and develop manufacturing processes. Another important function of R&D department is to troubleshoot and support manufacturing. Sales, General and Marketing (S,G&A) department of a pharmaceutical firm are responsible for branding, pricing, marketing, communication, sales etc. They ensure that their product reaches customers and revenue is generated by product or service. Wages, salaries and expenses to workers employed in R&D and S,G&A departments is considered as investment. For VAIC calculation, only High skilled human capital will be considered.

Another resource available to a firm through which value can be created is called structural capital. Structural capital is defined as supportive infrastructure of a firm that enable human capital to function. According to Pulic, this is defined as value added after deduction of human

capital expenditure. In the context of pharmaceutical industry, this includes planning, scheduling, process management, structural organization of workforce, documentation processes etc. All these processes function as a supportive infrastructure for human capital to function and convert raw materials into products and services.

Use of human capital and structural capital varies between firms. Management of a company decides on R&D expenditure, number of scientist to be employed, marketing expenditure, sales strategy etc. In order to understand and measure the impact of decisions made by management of a firm, Pulic uses the concept of efficiency. Pulic introduces two independent variables that measure efficiency of utilization of human capital and structural capital. These variables are human capital efficiency (HCE) and structural capital efficiency (SCE).

In order to understand overall efficiency of a firm, we also need to consider efficiency of capital employed by the company. Biotechnology firms listed in NASDAQ biotech index have minimum market value of $200 million. Hence, these firms have physical infrastructure in the form of building, machinery, and financial capital in terms of cash and cash equivalents. Management of a firm decides how to utilize this infrastructure in order to do revenue generation and value creation. Efficiency with which capital is employed in value creation is very important in the survival and profit making of a firm. This efficiency is measure through the concept of capital employed efficiency (CEE)

From the above discussion, three key independent variables can be shortlisted that measure overall efficiency of a firm. These variables are

i) Human capital efficiency (HCE)

ii) Structural capital efficiency (SCE)

iii) Capital employed efficiency (CEE)

HCE and SCE depend on the intellectual ability of the people employed. Summation of these two variables is defined as intellectual capital efficiency (ICE). Summation of all three independent variables (HCE, SCE and CEE) is defined as VAIC (Value added intellectual coefficient). VAIC as a efficiency index informs management, investors and other stakeholders about the utilization of resources and helps to perform comparative analysis between two or more firms.

VAIC = HCE + SCE + CEE or

VAIC = ICE + CEE

3.4 VAIC Calculation

VAIC is calculated through 5 basic steps as described by Pulic (Pulic, 1999). One of the advantage of using VAIC to measure firm value efficiency is that the calculation of VAIC is based on accounting data published by a firm. All data is taken from a firm's balance sheet, income statement and annual report.

i) First step in measuring VAIC is to calculate value added (VA). Value added is defined as difference between output and input. Here, output equals revenue from all products and services that the firm has to offer in a market. Input, consist of all expenses that were needed to manufacture all the products or provide all services.

VA = OUTPUT - INPUT

OUTPUT = Total sales, INPUT = Cost of bought-in materials, VA = Value added for the company

or

VA = P + C + D + A

P = Operating profit, C = Employee costs, D = Depreciation, A = Amortization

Calculation of VA can also be calculated using a more detailed approach as described by Riahi-Belkaoui (Riahi-Belkaoui, 2003) .

R = S - B - DP - W - I - DD - T

R = retained earnings, S = net sales revenue, B = Bought-in materials and services,
DP = Depreciation, W = Wages, DD = Dividends, T = Taxes

This equation can be re written as

VA = S-B -DP = W + I + DD + T + R

The term on the left hand side of the equations is termed as net value added. Right hand side of the equation represents distribution of value created by companies.

ii) Second step towards VAIC calculation is calculating capital employed by the firm. Capital employed (CE) includes both physical and financial capital.

Capital employed is calculated by

CE = physical capital + financial assets (by definition) i.e.

CE = Total assets - intangible assets (data available in balance sheet)

From VA and CE, we can derive the capital employed efficiency (CEE)

CEE = VA / CE - (Equation 1)

iii) Third step in VAIC calculation is calculating human capital efficiency (HCE). As explained in section 3.2, in this thesis only wages and expenditure on value added workers will be considered.

HC = human capital cost (only value added workers) = Wages and expenditure on R&D and Sales & general administration (SGA).

HCE = VA / HC - (Equation 2)

iv) Structural capital (SC) is defined as difference between value added and human capital cost, hence, less HC participates in value creation, the more SC is involved.

SC = VA - HC

Therefore, structural capital efficiency (SCE) is defined as ratio of structural capital and value added. This is because HC and SC are inversely proportional.

SCE = SC / VA - (Equation 3)

v) Last step towards VAIC calculation is summation of equation 1,2 and 3.

VAIC = CEE + HCE + SCE

VAIC refers to overall efficiency of a firm

4. Results and Analysis

This chapter summarizes all the results in this research thesis . It consist of 4 sections 4.1) Descriptive statistics 4.2) Exploring assumptions 4.3) Regression analysis

4.1 Descriptive Statistics

In this section, descriptive data of all dependent and independent variables for 2011, 2012 and 2013 will be tabulated. Each table below shows descriptive statistics of all dependent variables (ROE and M/B) and independent variables (VAIC, CEE,HCE and SCE) for each year.

Variables	Minimum	Maximum	Mean	Standard Deviation
Sample Size	53			
M/B	1.00	23.60	5.27	4.63
ROE	-2.46	1.12	-0.23	0.76
VAIC	-47.09	5.00	-0.91	9.40
CEE	0.01	1.79	0.52	0.36
HCE	0.02	3.78	1.16	0.803
SCE	-47.13	0.74	-2.69	8.83

Table 3: Descriptive statistics for selected variables (2011 data)

Variables	Minimum	Maximum	Mean	Standard Deviation
Sample Size	53			
M/B	0.79	20.04	4.76	3.68
ROE	-1.62	0.87	-0.16	0.53
VAIC	-74.63	4.77	-2.29	13.49
CEE	0.01	1.32	0.45	0.32
HCE	0.01	3.57	1.06	0.80
SCE	-74.63	0.72	-3.82	13.00

Table 4: Descriptive statistics for selected variables (2012 data)

Variables	Minimum	Maximum	Mean	Standard Deviation
Sample Size	52			
M/B	1.12	20.88	7.12	4.77
ROE	-2.99	0.71	-0.22	0.58
VAIC	-912.92	4.75	-20.17	126.91
CEE	-10.19	2.34	0.22	1.61
HCE	0.00	3.35	1.01	0.78
SCE	-912.92	0.70	-21.40	126.68

Table 5: Descriptive statistics for selected variables (2013 data)

The above three tables show the descriptive statistics of biotechnology / pharmaceutical firms listed in NASDAQ biotech index. All the companies for each year had a M/B ratio of greater than 4. This suggest that on an average, market values biotechnology firms four times their book value. On average, return on equity for biotech firm is negative. This implies that biotechnology firms have a negative net income. In other words, they are a loss making venture (in general).

4.2 Exploring Assumptions

4.2.1 Checking for Normality

(For all Residual plots, QQ plots and histograms, check APPENDIX I)

Two variables have been checked for their normality. These are dependent variable namely a) M/B : Market to Book Ratio (M/B) b) ROE : Return on Equity (ROE)

In order to check for normality, 4 parameters were evaluated. These are Kolgomorov Smirnov (KS) value, Shapiro Wilk (SW) value, QQ plot, residual plots and histogram. These five parameters were evaluated for the dependent variables (M/B & ROE) and their corresponding mathematical transformation (in cases where the variable was not normally distributed).

1) Normality Testing for 2011 data.

Year	Dependent Variable	Kolgomorov Smirnov		Shapiro Wilk	
		Statistic	Significance	Statistic	Significance
2011	M/B	0.209	0.000	0.758	0.000
	Log (M/B)	0.078	0.200*	0.976	0.366*
	ROE	0.172	0.000	0.900	0.000
	2^{ROE}	0.109	0.163*	0.934	0.006
* Significance greater than 0.05					

Table 6: KS and SW value of dependent variables (2011 data)

Based on KS value, SW value, QQ plot, residual plot and histogram, log transformed value of M/B data is normally distributed. Hence, for multi linear regression analysis, M/B (2011) data will be considered in its log transformed form. For ROE (2011) data, due to negative values log function cannot be used. While,2^{ROE} function has a significant KS value. This is also supported by QQ plot and histogram. Independent variables for multi linear regression analysis on 2011 data are Log(M/B) and 2^{ROE}.

ii) Normality Testing for 2012 data

Year	Dependent Variable	Kolgomorov Smirnov		Shapiro Wilk	
		Statistic	Significance	Statistic	Significance
2012	M/B	0.163	0.001	0.826	0.000
	Log (M/B)	0.086	0.200*	0.989	0.912*
	ROE	0.132	0.022	0.942	0.013
	2^{ROE}	0.087	0.200*	0.971	0.226*
*Significance greater than 0.05					

Table 7: KS and SW value for dependent variables (2012 data)

Log transformation was performed on 2012 M/B data, while 2012 ROE data was transformed using 2^{ROE} function. In both the cases of transformation, transformed data was normally distributed according to KS and SW value. Visual inspection of residual plots, QQ plot and histogram also show that transformed data for M/B and ROE is more normally distributed in comparison to raw data. Hence, for multi linear regression analysis of 2012 VAIC data, we will consider independent variables as Log (M/B) and 2^{ROE}.

iii) Normality testing for 2013 data

Year	Dependent Variable	Kolgomorov Smirnov		Shapiro Wilk	
		Statistic	Significance	Statistic	Significance
2013	M/B	0.133	0.022	0.915	0.001
	Log (M/B)	0.082	0.200*	0.977	0.393*
	ROE	0.148	0.006	0.806	0.000
	2^{ROE}	0.116	0.079*	0.97	0.218*
*Significance greater than 0.05					

Table 8: KS and SW value for dependent variables (2013 data)

2013 data for dependent variables M/B and ROE were not normally distributed according to KS ,SW values, QQ plot and residual plots. Hence, M/B was transformed using log function. KS and SW value for transformed function was significant (greater than 0.05). ROE function was transformed using 2^{ROE} function. In both the transformation cases, KS and SW values were significant.

Along with KS and SW value, visual inspection of log transformed M/B data using residual plot, QQ plot and histogram suggest that the data is normally distributed. Hence, for multi linear regression analysis, log transformed M/B data (2013) will be utilized. Similarly for ROE, 2^{ROE} transformed data will be utilized.

In summary, for all 3 years log transformed M/B data will be utilized as an dependent variable. For ROE, 2^{ROE} transformed data will be utilized for all three years in multi linear regression analysis. Here, the idea is not to compare data for one year with another, but rather check whether VAIC methodology is correlated with traditional financial parameters for each year. Hence, different transformation for different year is justified.

4.2.2 Multi Collinearity

Checking the independent variables for multicollinearity is important before conducting multi linear regression analysis. Multicollinearity checks whether the independent variables are highly correlated. Multicollinearity means that one independent variable can be predicted from another independent variable. In such a case of high correlation between two independent variables, coefficient estimates in a multi linear regression may change erratically in response to small changes in the data. Hence, multicollinearity affects calculations regarding individual predictors.

In order to check for multicollinearity, variance inflation factor (VIF) and tolerance value (1/VIF) are calculated. According to Myers (Myers, 1990), multicollinearity is a problem when VIF is greater than 10 or tolerance value is less than 0.1. In this thesis, we have three independent variables, namely HCE, SCE and CEE. Multicollinearity of each independent variable for each year will be checked with other independent variable for the same year. For example, multicollinearity of HCE (2011) will be checked with SCE (2011) and CEE (2011). Hence, total of 6 VIF values will be evaluated for each year.

i) Multicollinearity of independent variables for 2011 data.

Multicollinearity data check for 2011 independent data (n=53)			
Independent Variable	**Variables for check**	**Tolerance**	**VIF**
2^{ROE}	HCE	0.653	1.532
	SCE	0.747	1.338
	CEE	0.679	1.472
Log (M/B)	HCE	0.653	1.532
	CEE	0.747	1.338
	HCE	0.679	1.472

Table 9: Multicolinearity check for independent variables (2011 data)

ii) Multicollinearity of independent variables for 2012 data

Multicollinearity data check for 2012 independent data (n=53)			
Independent Variable	**Variables for check**	**Tolerance**	**VIF**
2^{ROE}	HCE	0.615	1.627
	SCE	0.792	1.262
	CEE	0.610	1.640
Log (M/B)	HCE	0.615	1.627

	CEE	0.792	1.262
	HCE	0.610	1.640

Table 10: Multicolinearity check for independent variables (2012 data)

iii) Multicollinearity of independent variables for 2013 data

Multicollinearity data check for 2013 independent data (n=52)			
Independent Variable	**Variables for check**	**Tolerance**	**VIF**
2^{ROE}	HCE	0.942	1.061
	SCE	0.951	1.051
	CEE	0.990	1.010
Log (M/B)	HCE	0.942	1.061
	CEE	0.951	1.051
	HCE	0.990	1.010

Table 11:Multicolinearity check for independent variables (2013 data)

For all three years and all three independent variables, no multicollinearity was discovered.

4.3 Regression Analysis

In this section, I will discuss the results of correlation analysis and regression analysis between independent and dependent variables. To summarize from introduction and conceptual framework, the goal of this thesis is to investigate whether higher firm efficiency (VAIC) has an

influence on a firm's traditional financial parameters. In this research thesis, an investor is the main stakeholder. Hence, dependent variables like M/B and ROE were selected. Data for each year (2011, 2012 and 2013) will be discussed separately. From section 4.1, dependent variables (M/B and ROE) were transformed. Table 12 summarizes the transformations done for converting non normal data to normally distributed data.

Data from Year	Variable	Transformation
2011	M/B	Log(M/B)
2011	ROE	2^{ROE}
2012	M/B	Log(M/B)
2012	ROE	2^{ROE}
2013	M/B	Log(M/B)
2013	ROE	2^{ROE}

Table 12: Summary of data transformations

This section is further sub divided into three parts. Section 4.3.1, will give an overview of relation between all variables through correlation analysis. Section 4.3.2, discusses linear regression analysis between dependent variables (M/B and ROE) and independent variable (VAIC). Section 4.3.3, will discuss effect of moderating variables. Section 4.3.4, will discuss multi linear regression analysis between dependent variables and components of VAIC (HCE, SCE and CEE).

4.3.1 Correlation analysis

Correlation analysis is the preliminary statistical technique to understand relationship between the dependent and independent variables. Tables in this section, shows correlation analysis of independent and dependent variables for each year.

Variables (n=53)		Log(M/B)	2^{ROE}	HCE	SCE	CEE	VAIC
LOG(M/B)	Pearson Correlation	1					
	Sig. (2-tailed)						
2^{ROE}	Pearson Correlation	-.103	1				
	Sig. (2-tailed)	.463					
HCE	Pearson Correlation	-.010	.701**	1			
	Sig. (2-tailed)	.944	.000				
SCE	Pearson Correlation	.110	.446**	.457**	1		
	Sig. (2-tailed)	.432	.001	.001			
CEE	Pearson Correlation	.199	.526**	.530**	.420**	1	
	Sig. (2-tailed)	.153	.000	.000	.002		
VAIC	Pearson Correlation	.111	.499**	.535**	.995**	.479**	1
	Sig. (2-tailed)	.431	.000	.000	.000	.000	

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed)

Table 13: Correlation analysis for 2011 data

Variables (n=53)		log(M/B)	2^{ROE}	HCE	SCE	CEE	VAIC
log(M/B)	Pearson Correlation	1					
	Sig. (2-tailed)						
2^{ROE}	Pearson Correlation	-.201	1				
	Sig. (2-tailed)	.149					
HCE	Pearson Correlation	-.093	.685**	1			
	Sig. (2-tailed)	.509	.000				
SCE	Pearson Correlation	.042	.255	.403**	1		
	Sig. (2-tailed)	.768	.066	.003			
CEE	Pearson Correlation	-.029	.657**	.596**	.411**	1	
	Sig. (2-tailed)	.837	.000	.000	.002		
VAIC	Pearson Correlation	.034	.302*	.462**	.998**	.456**	1
	Sig. (2-tailed)	.810	.028	.000	.000	.001	
**. Correlation is significant at the 0.05 level (2-tailed).							

Table 14: Correlation analysis for 2012 data

Variables (n=52)		Log(M/B)	2^{ROE}	HCE	SCE	CEE	VAIC
Log(M/B)	Pearson Correlation	1					
	Sig. (2-tailed)						
2^{ROE}	Pearson Correlation	-.092	1				
	Sig. (2-tailed)	.514					
HCE	Pearson Correlation	-.089	.653**	1			
	Sig. (2-tailed)	.531	.000				
SCE	Pearson Correlation	.038	.117	.220	1		
	Sig. (2-tailed)	.789	.408	.116			
CEE	Pearson Correlation	.206	.080	.100	.023	1	
	Sig. (2-tailed)	.143	.572	.480	.871		
VAIC	Pearson Correlation	.040	.122	.228	1.000**	.036	1
	Sig. (2-tailed)	.778	.389	.105	.000	.798	
**. Correlation is significant at 0.05 level (2-tailed)							

Table 15: Correlation analysis for 2013 data

Variables (n=157)		Log(M/B)	2^{ROE}	HCE	SCE	CEE	VAIC
Log(M/B)	Pearson Correlation	1					
	Sig. (2-tailed)	.000					
2^{ROE}	Pearson Correlation	-.139	1				
	Sig. (2-tailed)	.082	.000				
HCE	Pearson Correlation	-.073	.675**	1			
	Sig. (2-tailed)	.364	.000	.000			
SCE	Pearson Correlation	.087	.284**	.417**	1		
	Sig. (2-tailed)	.276	.001	.000	.000		
CEE	Pearson Correlation	.100	.192**	.194**	.119*	1	
	Sig. (2-tailed)	.213	.016	.015	.137	.000	
VAIC	Pearson Correlation	.087	.332	.480	.994	.207**	1
	Sig. (2-tailed)	.279	.000	.000	.000	.009	.000
**. Correlation is significant at 0.05 level (2-tailed)							

Table 16: Correlation analysis for all three years combined.

Correlation analysis for all three years is shown in table 16. Pearson pair wise correlation indicate that HCE is positively correlated with ROE (for all three years). For 2011 data, all the independent variables are strongly correlated with ROE ($p<0.01$). For all years, M/B is not significantly correlated with VAIC and its components. Overall, correlation analysis suggest that

firms with higher level of capital employed efficiency (CEE) and overall efficiency (VAIC) are correlated with return on equity (significant only for 2011 and 2012, not for 2013). While firms with higher level of human efficiency (HCE) are strongly associated with return on equity (for all three years). Hence, this implies that expenditure on research, marketing, sales etc can help in predicting return on equity of a firm.

Another observation from correlation data suggest that structural capital efficiency is highly correlated with VAIC (for all three years). This is primarily due to the way SCE is calculated. SCE is seen as value that is added due to structural capital. For companies, that have high human capital expenditure but low value addition (VA) have extreme negative structural capital. This leads to extreme negative SCE. These extreme values dominate in VAIC summation (see APPENDIX II). Due to this, VAIC and SCE are highly correlated. However, in regression model these two independent variables are not utilized in same model. Hence, it is not a cause of concern.

4.3.2 Linear Regression Analysis

This section, will discuss regression model of dependent variables and VAIC. Results are summarized in the table below. Linear regression equation is

Log (M/B) or $2^{ROE} = \alpha_0 + \alpha_1 . VAIC + \varepsilon$

		Log (M/B)	2^{ROE}
2011	n	53	53
	Adjusted R^2	-0.007	0.235
	F-statistics	0.631	16.944
	Significance	0.431	0.000
	Intercept	0.601	0.989
	Coefficient VAIC	0.04	0.022
2012	n	53	53
	Adjusted R^2	0.001	0.074
	F-statistics	0.058	5.133
	Significance	0.81	0.028
	Intercept	0.571	0.964
	Coefficient VAIC	0.001	0.007
2013	n	52	52
	Adjusted R^2	-0.018	-0.035
	F-statistics	0.080	2.813
	Significance	0.778	0.100
	Intercept	0.752	0.928
	Coefficient VAIC	0.000095	0.005

Table 17: Linear regression results

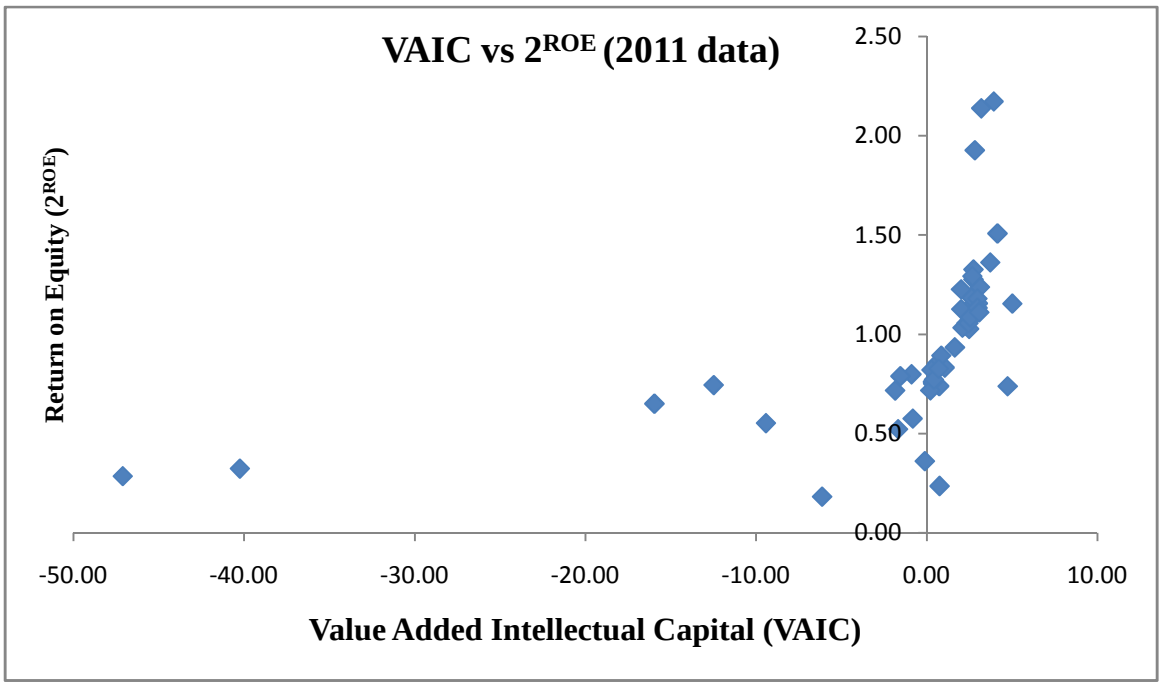

Figure 4: Linear Regression Graph (VAIC vs ROE,2011 data)

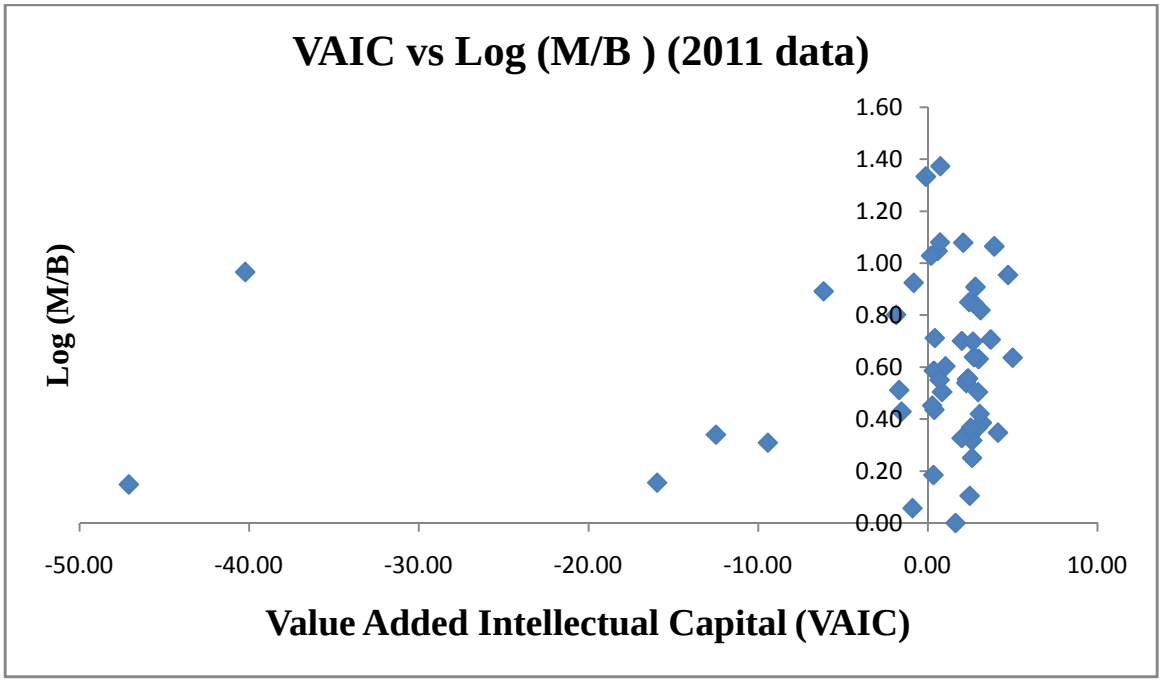

Figure 5: Linear Regression Graph (VAIC vs M/B, 2011 data)

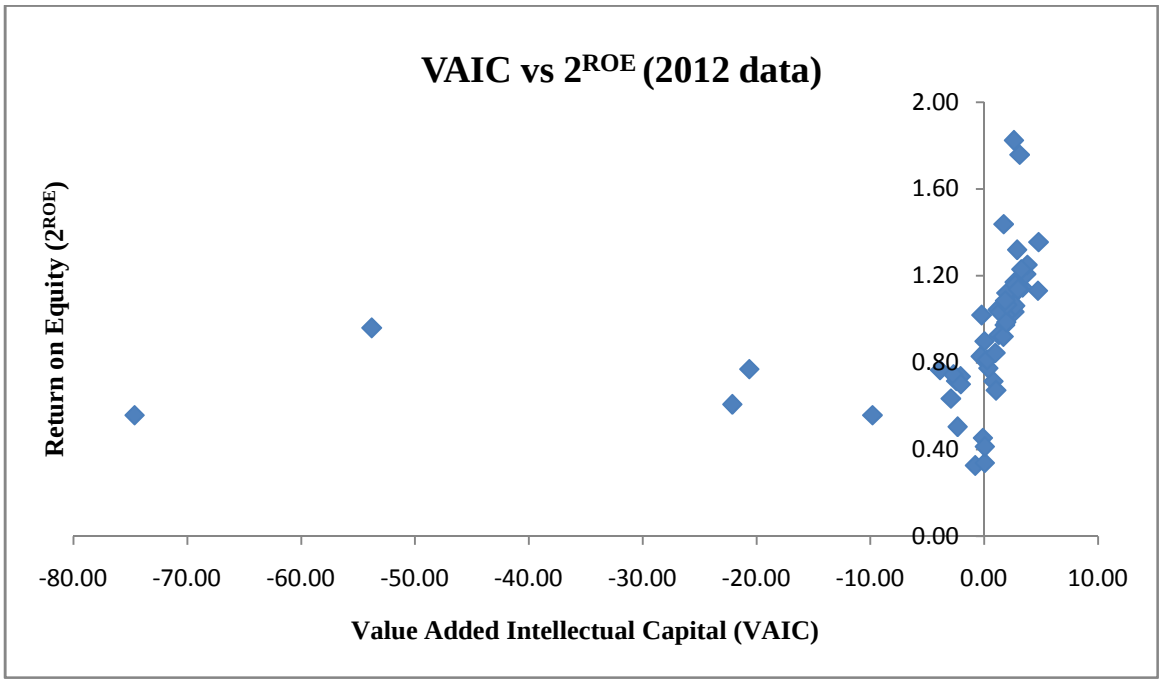

Figure 6: Linear Regression Graph (VAIC vs ROE, 2012 data)

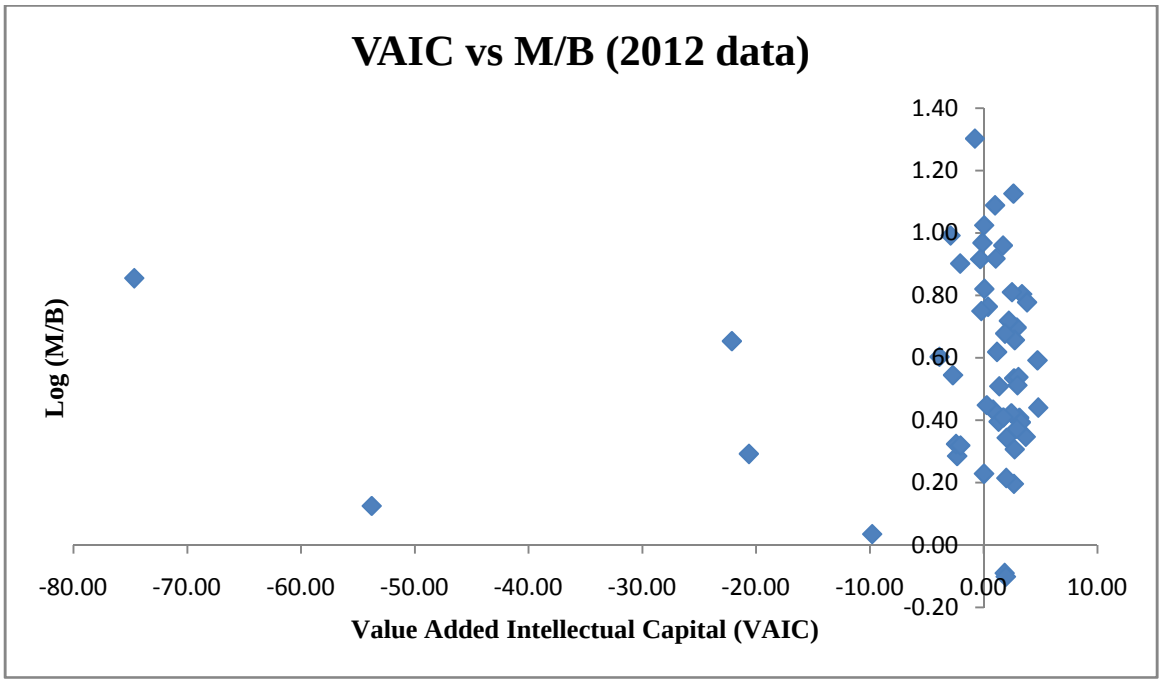

Figure 7: Linear Regression Graph (VAIC vs M/B, 2012 data)

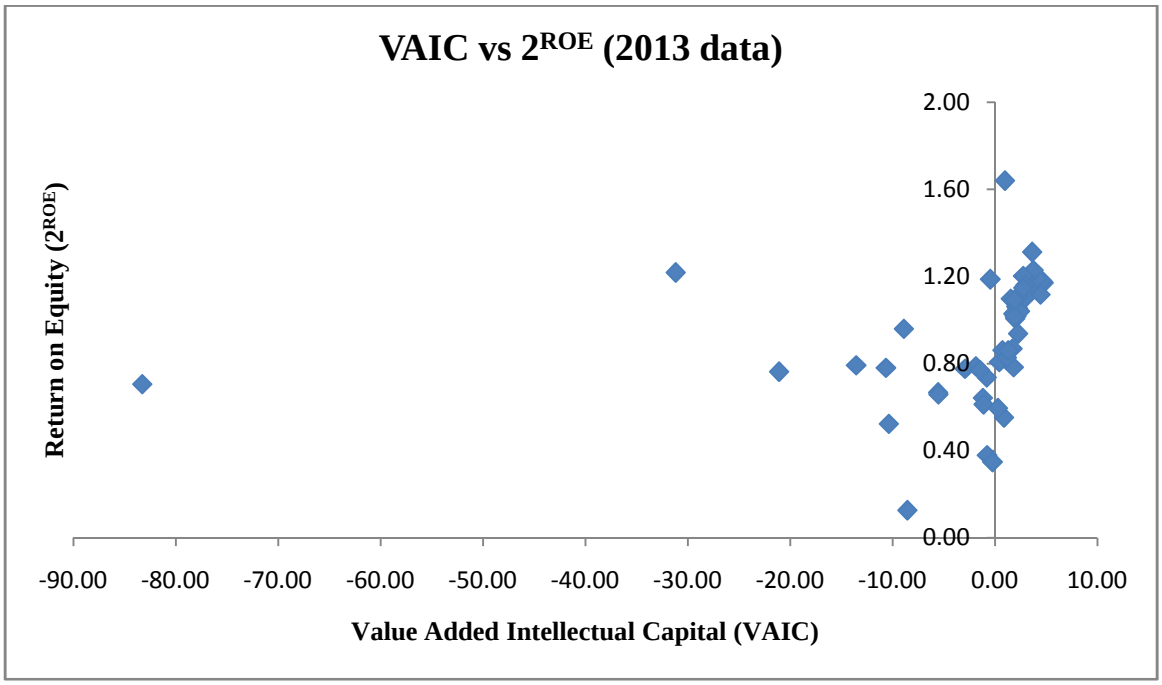

Figure 8: Linear Regression Graph (VAIC vs ROE, 2013 data)

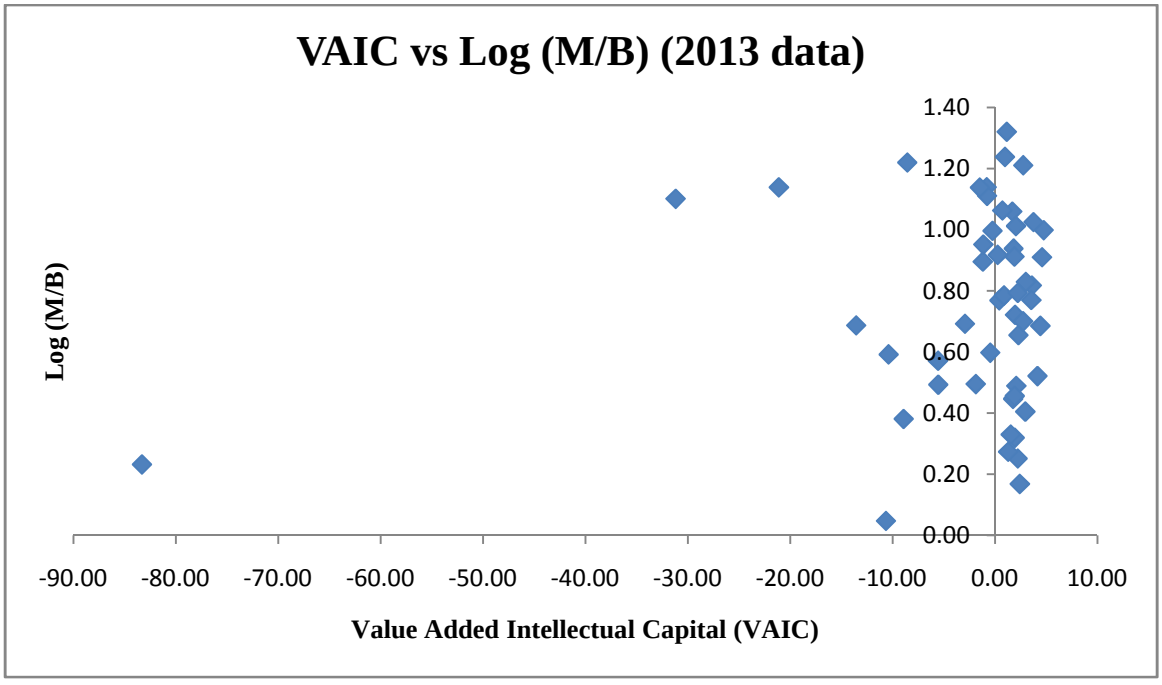

Figure 9: Linear Regression Graph (VAIC vs M/B, 2013 data)

From the above table, there is no statistically significant relationship between market to book ratio and VAIC. This implies that market perception (demand) of a firm does not consider firm value efficiency in its decision making process. For 2011 and 2012 data, a statistically significant relationship exist between ROE and VAIC (See figure 4 and 5). However, for 2013 data this relationship between ROE and VAIC breaks down and is not statistically significant. This may be due to the extreme VAIC outlier of -83.28 (See figure 6) . This data point was not removed as nothing suspicious was seen in the balance sheet of the respective firm. In all the three data sets, there were extreme outliers. These companies were not eliminated from data set . Annual reports of these companies (with negative VAIC) were studied. No major accounting abnormalities were found in reporting. Hence these data points were not eliminated from data set.

Hence from above result, H1 hypothesis is rejected, while H2 hypothesis is accepted for year 2011 and 2012. Hence, we can conclude that ROE has significant relationship with VAIC. Further in-depth analysis was conducted on the basis of age of firm (IPO date) and size of the firm (market valuation).

4.3.3 Effect of moderating variables

In statistics, moderation happens when relationship between independent and dependent variable depends on a third variable. This third variable is known as moderating variable.

According to Theodare Paul Wright (Wright, 1936), production cost is dependent on a firm's learning curve. In turn, rate of learning is also time dependent. This learning curve concept can be extrapolated to understand that as production cost decreases, firms revenue increases leading

to increase in firm size. Hence, in this thesis I will be investigating effect of two moderating variables, namely Firm Size (market value) and Age of Firm (IPO launch date).

i) Firm Size

NASDAQ biotech index consist of firms that are either categorized as small cap, mid cap and large cap (cap stands for capitalization). Small cap are the firms that have market valuation between 200 million USD to 2 billion USD. Mid cap are the firms that have market valuation greater than 2 billion USD but less than 10 billion USD. Firms having market valuation above 10 billion USD are categorized as large cap. According to learning curve theory, a firm that gains greater experience, increases its size. This leads to decrease in unit production and cost. Decrease in production cost or service, leads to higher profit. Hence, it can be theorized that firms with higher market valuation (size) have better efficiency in their production. This efficiency can translate into higher net income which should be reflected in higher ROE. Moderating model is

$2^{ROE} = \alpha_0 + \alpha_1$ VAIC + α_3 (Firm Size) + α_4 (VAIC * Firm Size).

The last term is the model above is known as an interaction term. Through this interaction term we can evaluate what is the effect of moderating variable on the relationship between independent and dependent variable.

2^{ROE}	2011	2012	2013
n	53	53	52
Adjusted R^2	0.2866	0.1626	0.1330
Significance (Model)	0.0061	0.2025	0.0455
F-statistic	4.6509	1.5951	2.8840
Significance (Interaction term)	0.3490	0.9125	0.9791
Coefficient (Interaction term)	0.0000	0.000	0.000
**** Significance for p<0.05**			

Table 18: Moderation effect of firm's size

Table above illustrates the results for firm size as a moderating variable. For all three data sets, interaction term was not significant. Hence, firm size does not have any moderating effect on the relationship between firm value efficiency and ROE.

ii) Age of a firm (IPO launch date)

For this thesis, age of firm will be measured from the year in which the firm launched its IPO. IPO stands for initial public offering. Once a firm issues an IPO, it is no longer considered as a private firm, instead it has to comply by financial regulations and disclose all information. After an IPO, firm is considered as a public firm. Once a firm becomes public limited, it has to release all its financial statements in the public domain and has to undergo audit by securities and

exchange commission. According to efficient market hypothesis (EMH), an IPO removes all information asymmetry leading to true market value of a firm. According to learning theory, a firm with greater experience (age) undergoes learning curve effect. Learning curve effect leads to firm becoming more efficient which gets reflected in lower production cost and higher profit. Hence, it can be theorized that firms with more experience (age) have better efficiency in their production. This efficiency can translate into higher net income which should be reflected in higher ROE

Model equation : ROE (transformed) = $\alpha_0 + \alpha_1$ VAIC + α_3 (Age of a firm) + α_4 (VAIC * Age of firm).

2^{ROE}	2011	2012	2013
N	53	53	52
Adjusted R^2	0.2561	0.1015	0.3261
Significance (Model)	0.0211	0.8437	0.0016
F-statistic	3.5438	0.2743	5.9488
Significance (Interaction term)	0.8945	0.9950	0.0014**
Coefficient (Interaction term)	0.0060	0.000	0.0027
**** Significance for p<0.05**			

Table 19: Moderation effect of firm's age

Table above illustrates the results for age of firm as a moderating variable. For 2011 and 2012 data sets, effect of age of firm as a moderating variable was not significant. While for 2013 data

set, effect of moderating variable was significant. However, since effect of moderating variable was not observed in two years out of three years, it is safe to conclude that there is no moderating effect of age of a firm on the relationship between ROE and VAIC.

From the above results, H3a, H3b, H4a and H4b hypothesis are rejected as p-value for interaction term is greater than 0.05.

4.3.4 Multi linear regression analysis

In this section, relationship between VAIC components (as independent variables) namely human capital efficiency (HCE), structural capital efficiency (SCE) and capital employed efficiency (CEE) with dependent variables of ROE and M/B. Results are tabulated below according to the year. The main model is

$$\text{Log (M/B) or } 2^{ROE} = \alpha_0 + \alpha_1 HCE + \alpha_2 SCE + \alpha_3 CEE + \varepsilon$$

	Dependent Variables			
	Log(M/B)		**2^{ROE}**	
Independent Variable	Co-efficient	t-statistic	Co-efficient	t-statistic
Constant	0.573	5.576	0.552	6.027
HCE	-0.076	-1.100	**0.279**	**4.556**
SCE	0.003	0.538	0.005	1.036
CEE	0.230	1.566	0.206	1.573
Adjusted R^2	0.006		0.507	
F-value	1.109		18.791	

Table 20: Multi linear regression results-Financial performance and VAICs components (2011 data)

	Dependent Variable			
	Log (M/B)		2^{ROE}	
Independent Variable	Co-efficient	t-statistic	Co-efficient	t-statistics
Constant	0.627	6.669	0.555	8.906
HCE	-0.054	-0.770	**0.187**	**4.046**
SCE	0.002	0.570	-0.003	-1.051
CEE	0.016	0.092	**0.400**	**3.487**
Adjusted R^2	-0.044		0.549	
F-value	0.269		22.06	

Table 21: Multi linear regression results-Financial performance and VAICs components (2012 data)

	Dependent Variable			
	Log(M/B)		2^{ROE}	
Independent Variable	Co-efficient	t-statistic	Co-efficient	t-statistics
Constant	0.793	10.668	0.589	8.664
HCE	-.049	-0.858	**0.237**	**5.852**
SCE	0.000	0.420	-0.000615	-0.252
CEE	0.042	1.540	0.003	0.136
Adjusted R^2	-0.001		0.392	
F-value	0.984		11.965	

Table 22: Multi linear regression results-Financial performance and VAICs components (2013 data)

Above tables list down all coefficients and t-statistics of VAIC components and its relationship with dependent variables for year 2011, 2012 and 2013. For each year, no statistically significant relationship between market to book ratio and components of VAIC was discovered. Hence, VAIC components of human capital efficiency, structural capital efficiency and capital employed efficiency are poor indicators to predict market valuation of a firm. This also implies that investors don't consider efficiency of a firm while evaluating its market value.

ROE as a dependent variable for 2011 and 2012 was significantly positively associated with HCE. ROE was significantly positively associated with CEE for year 2012. Table below summarizes all the results for the hypothesis proposed in section 3.1.

H1	Not Supported
H1a	Not supported
H1b	Not supported
H1c	Not supported
H2	Supported
H2a	Supported
H2b	Not supported
H2c	Not supported

Table 23: Result summary of all hypothesis

5. Discussion and Conclusion

5.1 Discussion

Overall, the empirical findings based on correlation and regression analysis, show that association between firm value efficiency and traditional financial parameters of M/B and ROE is limited and mixed. Firm value efficiency is significantly positively associated with ROE. However, variance explanation varies, from 23 % in 2011 to ~ 1 per cent in 2012. While, no correlation was discovered between VAIC and M/B. VAIC relationship with ROE was significantly positive for 2011 and 2012. For 2013, initial analysis showed no significant relationship. On closer inspection, this was mainly due to a data point that represented Oncothyreon pharmaceutical. This firm had unusual extreme negative VAIC value of -83.36.. Their annual report showed very low revenue generation and high expenditure on R&D and sales & marketing. Due to this unusual distribution, it led to extreme high negative SCE, which in turn dominated VAIC calculation. Hence, the regression model becomes insignificant. Elimination of this data point made the relationship between VAIC and ROE significant. Since, no suspicious reporting was observed for Oncothyreon pharmaceutical, it was not removed from the data set.

Purpose of this study was also to investigate relationship between ROE and VAIC components, namely HCE, SCE and CEE. For all three data set (2011, 2012 and 2013), human capital efficiency had moderately positive association with ROE. This implies that profitability of publicly traded biotech firms in US depends on management of human capital. However, human capital efficiency only explained ~30% of variance in ROE. This can translate into higher productivity of employees, project based employment, hiring of few permanent employees, etc.

According to VAIC calculation methodology, firms that have human capital expenditure greater than value addition, have negative structural capital. This is true for companies that are still researching and developing drugs, but still haven't started FDA approval to release it in market. This leads to extreme negative VAIC values. This can be seen as a drawback of VAIC methodology calculation. VAIC methodology incorrectly measures firm efficiency for companies that are still in R&D phase or don't have a product in market. One way to correct this bias /error is to only consider firms that have HC > VA or consider firms that have atleast one major product in market. This argument has also been provided by G.Iazzolino and D.Laise (Iazzolino et al, 2013).

No correlation was discovered between SCE and ROE. This can be understood by understanding structural capital in detail for biotechnology / pharmaceutical industry. Most drug manufacturing firms have lot of quality control, quality assurance and documentation processes in place. These processes in general don't translate into cost reduction or increase in market share. However, these processes are very important from product quality, regulatory and legal point of view. Once these processes are implemented and approved by FDA, it is very difficult to change them. This is also evident by observing high negative structural capital values and structural capital efficiency (APPENDIX) for companies that do not have high revenue generation. These structural processes are not designed to contribute as differentiating factor or enhancing character to the product. Instead, these structural processes are mandatory requirements by law. This is one of the major difference between biotechnology / pharmaceutical industry and other industrial sector.

Capital employed efficiency had moderately positive association for 2012 data set. This association was not consistent for all three years. Hence, it is reasonable to reject this association between CEE and ROE. One of the main reason for this dis association is the manner in which manufacturing and assets are utilized by biotechnology firms. Large biotechnology firms with substantial financial capital, normally internalize their manufacturing process. This leads to higher capital expenditure initially, but overtime leads to decrease in production cost, higher value creation and better efficiency. For small and medium size biotech firms, they lack the capital to internalize and setup their own manufacturing facility. Hence, they work with contract manufacturing organizations (CMOs) for production and manufacturing. Hence, cost of manufacturing does not decrease substantially over period of time, leading to stagnant capital efficiency.

Finally, empirical findings on moderating variable like size and age of a firm did not yield any association. Hence, biotechnology firms do not necessarily undergo learning curve that translates into value generation as suggested by Theodore Paul Wright (Wright, 1936). In order to understand lack of effect of moderating variables, it is imperative to understand technological advances and product development process in biotechnology industry. Unlike telecom, material science industries, most biotech inventions and discovery occur in academia research or existing firms. Hence these innovations can be easily transferred and utilized in existing processes by firms. For example, after 2000 DNA sequencing has redefined drug discovery processes. Due to this ease in transfer of innovation, firms (old or new) which are able to adopt and capitalize on it are able reduce their time from drug discovery to market. This results in higher revenue generation.

Results of this study is consistent with previous VAIC studies conducted in Taiwan and Singapore (Chen et al, 2005 ; Pew Tan et al, 2007). Common thing between above mentioned studies and this study is that all three studies were considered technologically advanced countries (Taiwan, Singapore and US). In contrast, VAIC studies done for companies in South Africa, Greece and Turkey (see literature review chapter) yielded no major correlation between VAIC and traditional financial parameters. This discrepancy between countries can help to understand which countries are progressing towards knowledge based economy, however it needs extensive data backed research.

5.3 Short comings of this research

In the course of research, I have found that two of the major shortcoming in VAIC calculation is that it cannot be applied to firms that have no or low revenue stream. In other words, it cannot help to understand efficiency of a firm that have no product or services in the market. This is mainly due to way VAIC is calculated. VAIC is summation of human, structural and capital efficiency. Since, a firm does not have a revenue stream (no value addition) and relatively high expenditure results in extreme negative structural capital. Hence, VAIC value will be dominated by extreme negative value. These data points in a regression analysis distort the result. Hence, for future research, it is imperative to have a better data collection strategy. This means that a thorough analysis of firms needs to conducted before selecting them for VAIC analysis. Researcher can shortlist firms in various ways, one of the easiest way to screen is to select firms that have VA value greater than HC value. Another way to screen firms is to select firms that have at least one product in the market.

Another shortcoming of this research is that it failed to identify VAIC components in detail. In this research thesis, VAIC components have been identified based on Pulic's VAIC method. In VAIC methodology , structural capital component is a viewed as all things other than human and capital that contribute towards value creation. An improved understanding and identification of components of structural capital needs to be made. In order to study structural capital in detail before a quantitative study, it is imperative to undertake a qualitative study before proceeding to quantitative study. An interview based qualitative study will help to indentify factors that affect value generation or contribute towards value generation. This interview based approach will also help in identifying components of structural capital. For example, structural capital components in biotechnology industry do not necessarily contribute towards value generation as most of them are legal and regulatory requirement. Hence, these components could have been removed beforehand to understand firm value efficiency in a better way.

These research findings can only be generalized to biotechnology / pharmaceutical firms in US. This may seem like a shortcoming of the research, but it in line with criticism by other researchers like Stahle and G.Iazzolino (Stahle et al, 2011 ; G. Iazzolino et al, 2013). Each industrial sector has its range of efficiency based on the value creation ability and resources utilized. Therefore, it would be not correct to compare results obtained for biotechnology industry with that of aviation industry. In addition, macroeconomic forces behave differently on different industrial sector and country. This can be understood by taking example of manufacturing. In clothing sector, cheap labor and tax incentives by Asian countries has resulted in a major shift of manufacturing from US and Europe. Hence value creation and proftability of firm operating in Asia with be different from firm having manufacturing operations in Europe.

Therefore, in order to do a comparative analysis and get a meaningful understanding of firm efficiency, it is important to calculate firm efficiency based on industry and country.

5.4 Recommendations and Practical Relevance

An investor / portfolio manager were considered as the main stake holder. All major investment firms hire medical doctors, biological scientist and other technical graduates as investment researchers. These employees are tasked to research on biotechnology firms. Based on their findings, a portfolio manager makes a decision to buy, sell or hold equity of a firm. Their main job is to forecast future growth of firm. Since these teams expensive to hire and small in size, not all public firms are scrutinized thoroughly. Findings in this research can be utilized to develop a software or an app to screen thousands of stocks.

EST can help a portfolio manager to shortlist most efficient firms, as these firms have most likelihood of giving good return on equity. Once this screening is completed, a more thorough analysis can be done by researchers. Figure 7 below explains a probable implementation plan based on the findings of this research. A detailed plan is beyond the scope of this thesis.

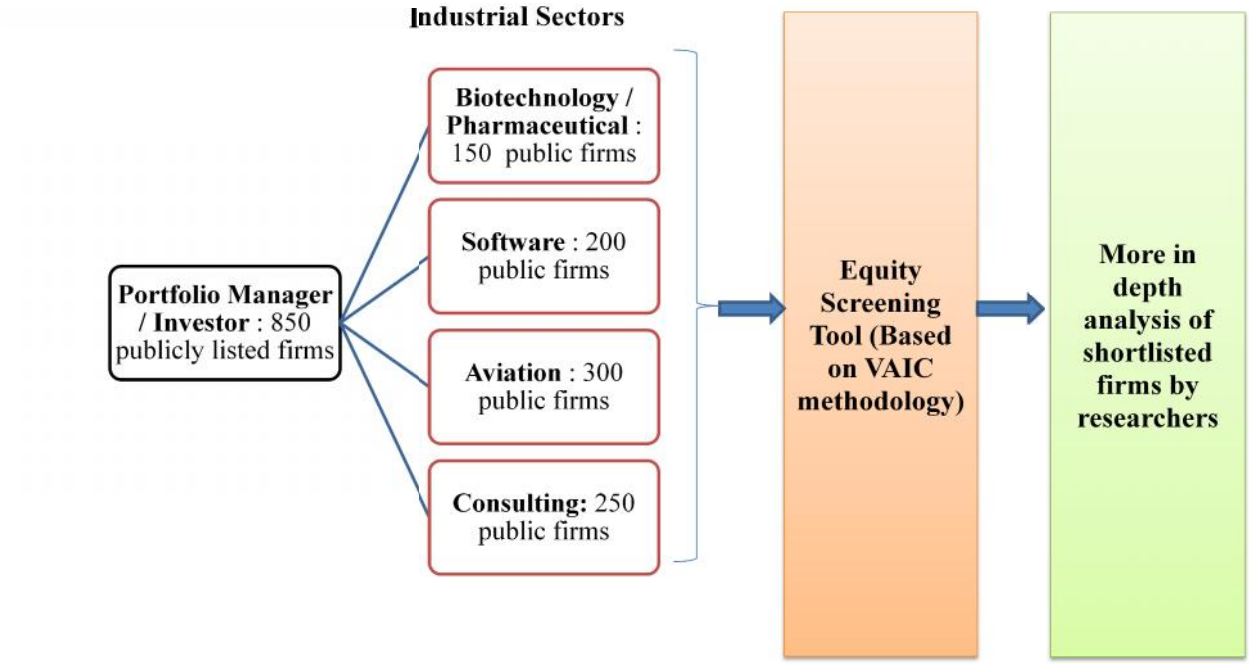

Figure 10: Implementation plan of VAIC methodology

5.5 Future Research

For future, similar research needs to be done for other industrial sector in a specified country. Once firm value efficiency is calculated for all other industrial sector, a VAIC map can be constructed to see which industrial sectors are most efficient in value creation and which industrial sections are least efficient in their value creation.

Similar, VAIC research can be conducted for other stakeholders like firm's management. In case of firm's management as a stake holder, return on asset (ROA) needs to be considered as a dependent variable.

5.6 Conclusion

As human population starts relying on technology, it is important to recognize strategic intellectual assets rather than regular tangible assets. One way to understand intangible assets and intellectual capital is by understanding their contribution towards overall firm value efficiency. This thesis provided empirical evidence that higher firm value efficiency for biotechnology firms in US contribute towards higher return on equity of a firm. However, no association between firm value efficiency and market to book ratio was found. In other words, investors don't consider efficiency of a firm or intellectual capital of a firm while valuing them. These results also confirmed relevance of VAIC methodology, however future research for other industrial sector is needed. Hence, external validity of this research is weak. Empirical evidence also suggested that human capital efficiency for a biotechnology firm in US has moderately positive correlation with return on equity but not with market to book ratio. Before doing this research, it is also imperative to develop a qualitative understanding of the industry under investigation. This kind of understanding helps to recognize factors that contribute towards value creation. In this research, lot of structural capital for a biotechnology industry is legal and regulatory requirement. Therefore, a qualitative research will help to break down components of structural capital. A follow up quantitative research will only consider those structural components that contribute towards value creation / value addition. For biotech industry, variables like size and age of firm do not exhibit any moderating effects between VAIC and ROE.

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APPENDIX I

QQ plots, Histograms and residual PP plots for Normality check

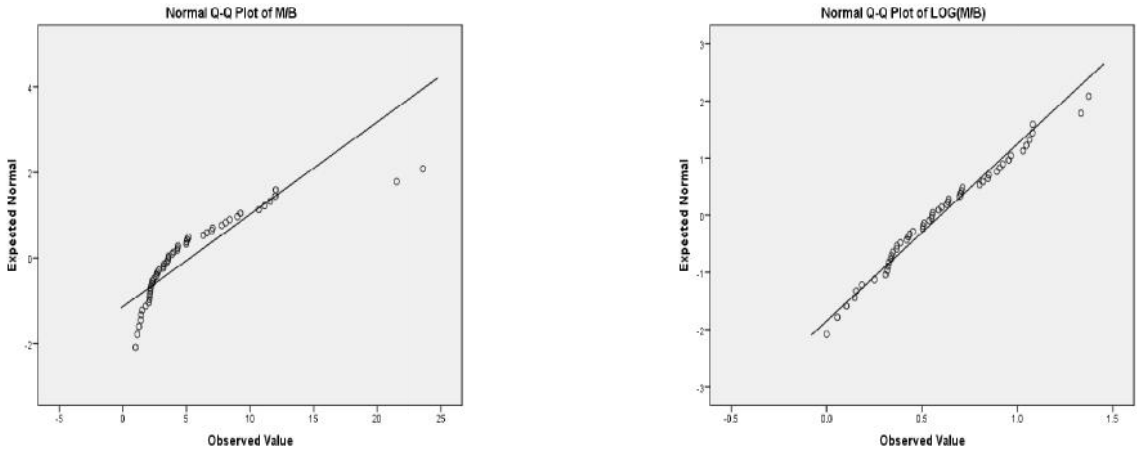


Figure i: QQ plot of M/B and Log (M/B) for 2011 data

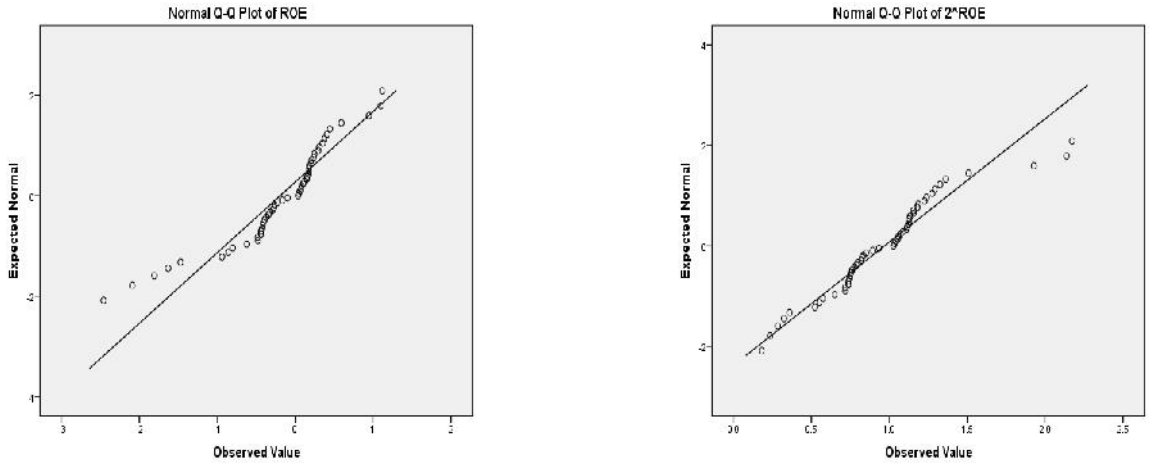


Figure ii: QQ plot of ROE and 2^{ROE} for 2011 data

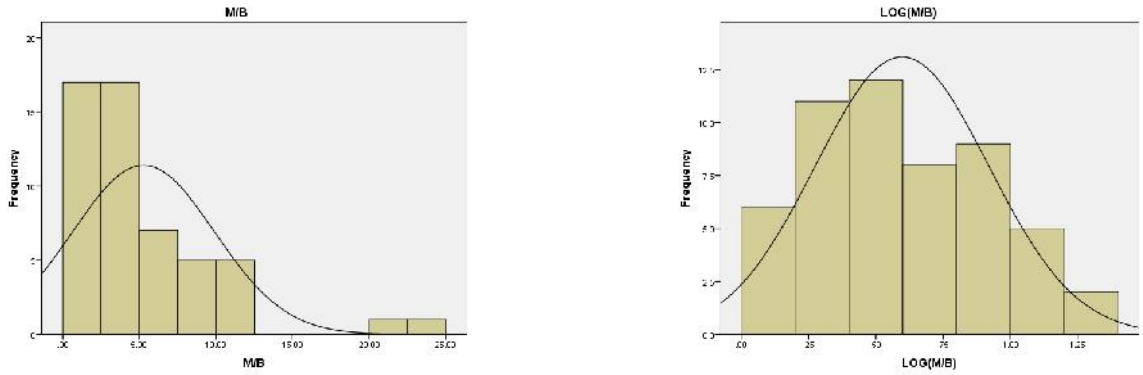


Figure iii: Histogram (with Normal Distribution) of M/B and LOG(M/B) for 2011 data

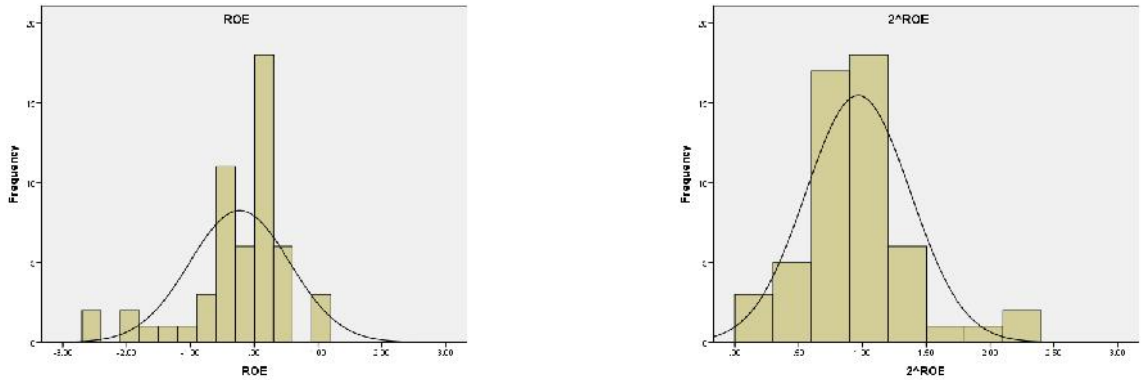


Figure iv: Histogram(with Normal Distribution) of ROE and 2^{ROE} for 2011 data

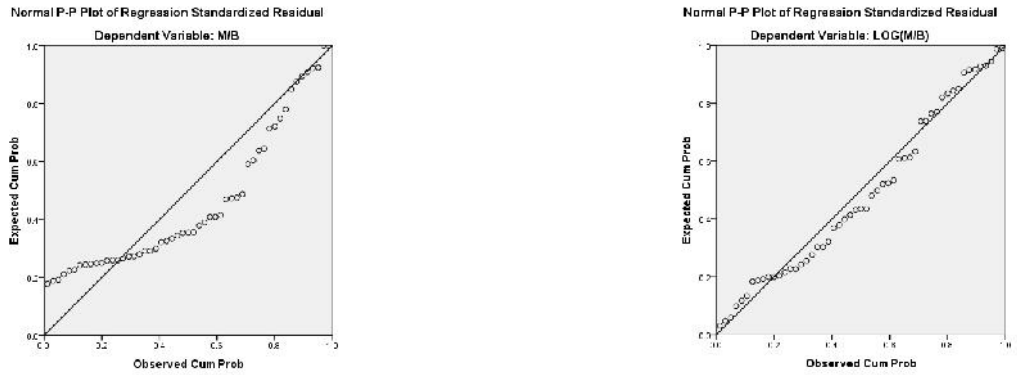
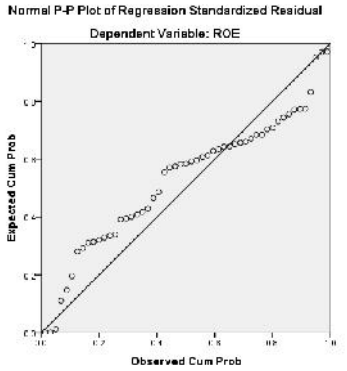


Figure v: Normal PP standardized residual plot of M/B and Log (M/B) for 2011 data



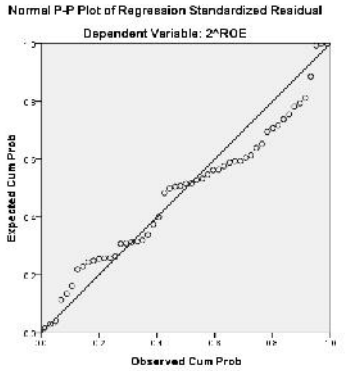
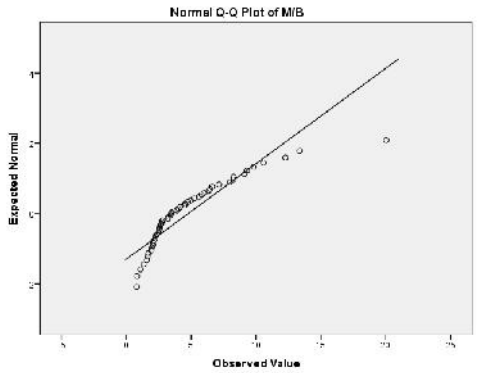


Figure vi: Normal PP standardized residual plot of ROE and 2^{ROE} for 2011 data

ii) Normality Testing for 2012 data



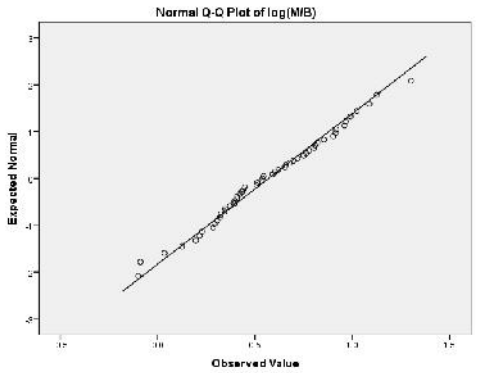
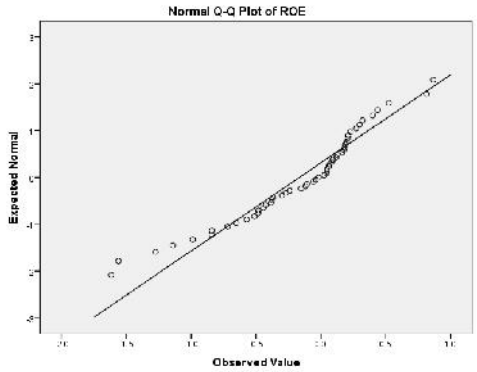


Figure vii: QQ Plots of M/B and Log (M/B) for 2012 data



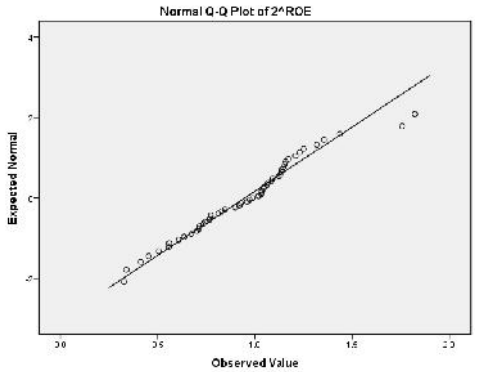


Figure viii: QQ Plots of ROE and 2^{ROE} for 2012 data

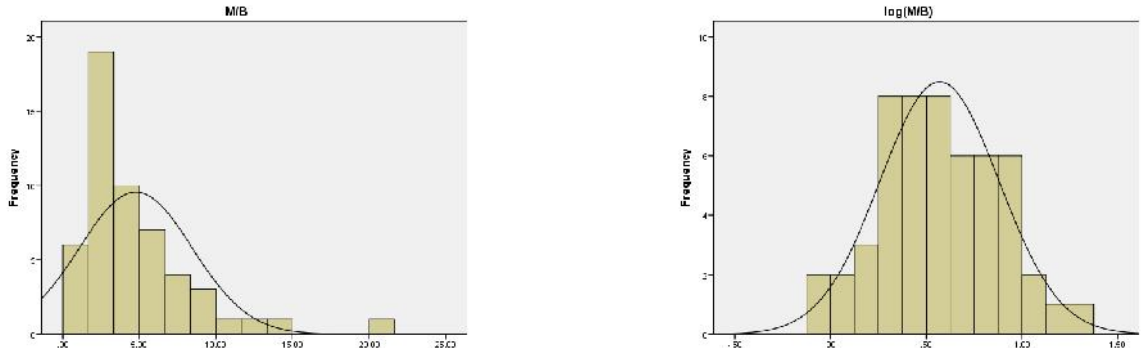


Figure ix: Histogram (with normal distribution curve) of M/B and Log (M/B) for 2012 data

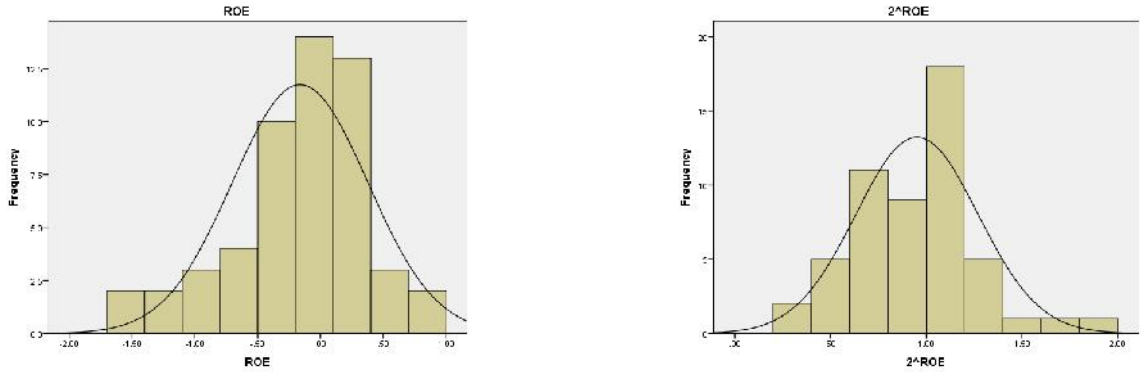


Figure x: Histogram (with normal distribution curve) of ROE and 2^{ROE} for 2012 data

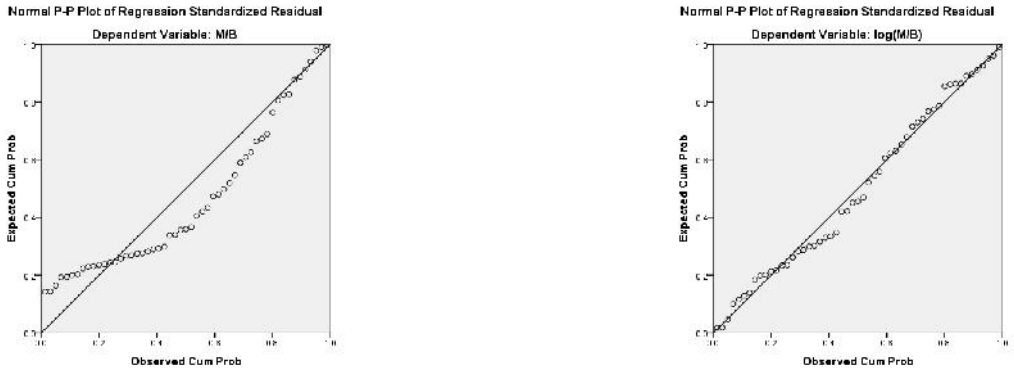
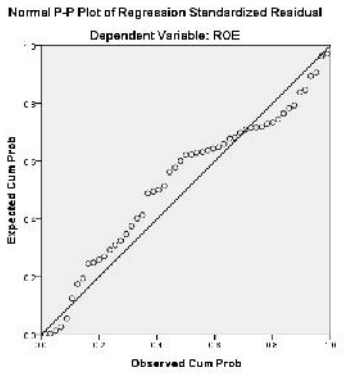


Figure xi: Normal PP standardized residual plot of M/B and Log (M/B) for 2012 data



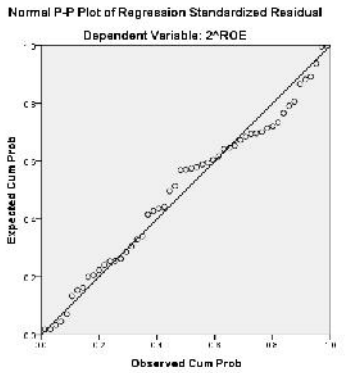
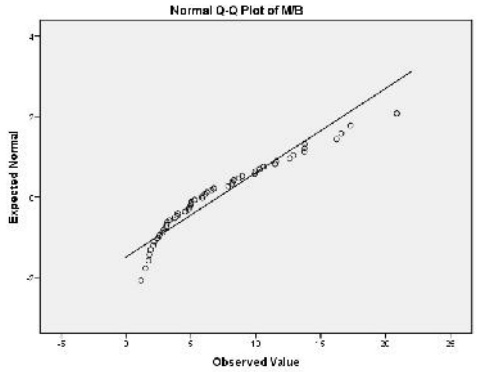


Figure xii: Normal PP standardized residual plot of ROE and 2^{ROE} for 2012 data

iii) Normality testing for 2013 data



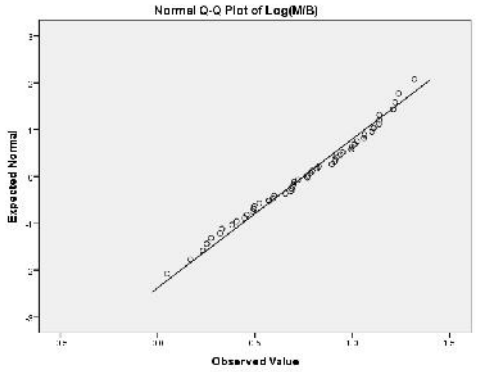
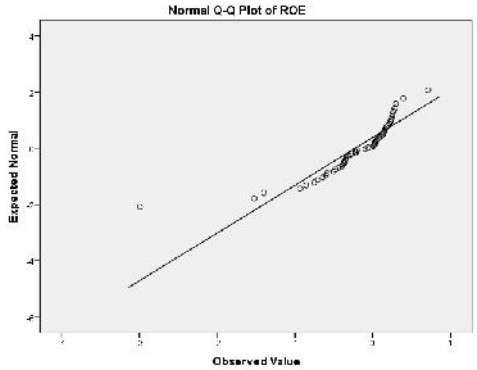


Figure xiii: QQ Plots of M/B and Log(M/B) for 2013 data



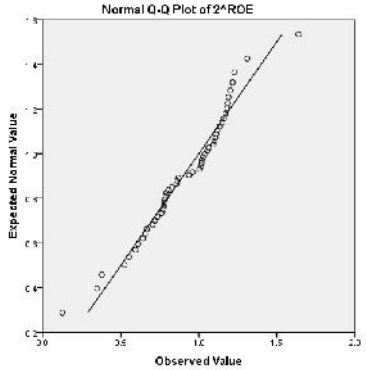


Figure xiv: QQ Plots of ROE and 2^{ROE} for 2013

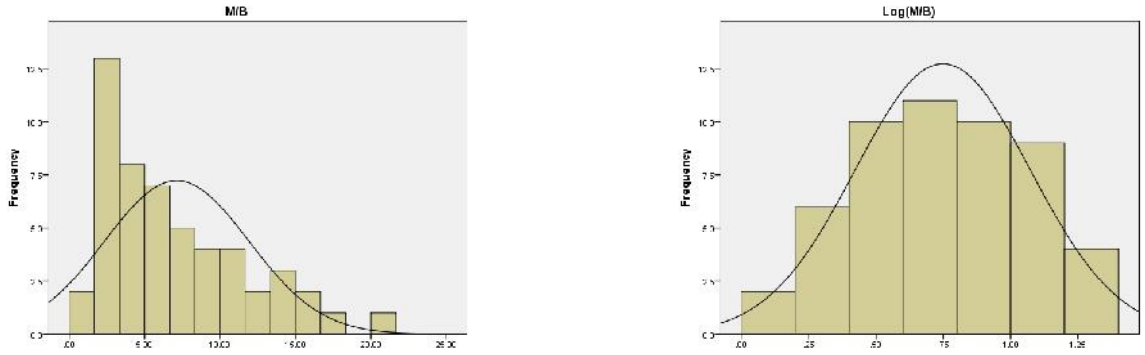


Figure xv: Histogram (with normal distribution curve) of M/B and Log(M/B) for 2013 data

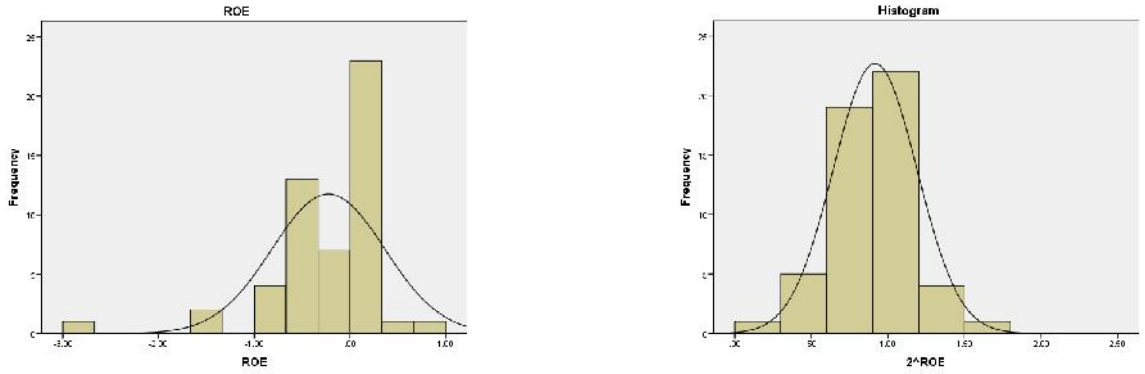


Figure xvi: Histogram (with normal distribution curve) of ROE and 2^{ROE} for 2013 data

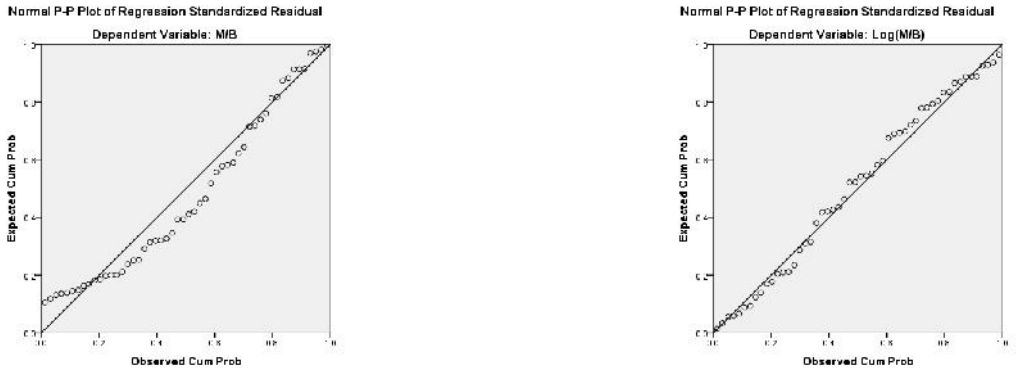
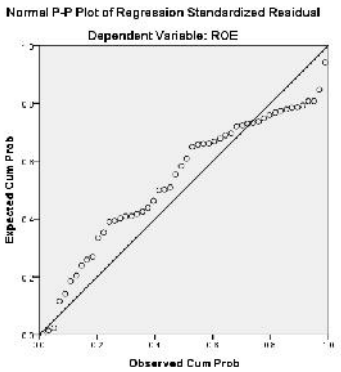


Figure xvii: Normal PP standardized residual plot of M/B and Log (M/B) for 2013 data



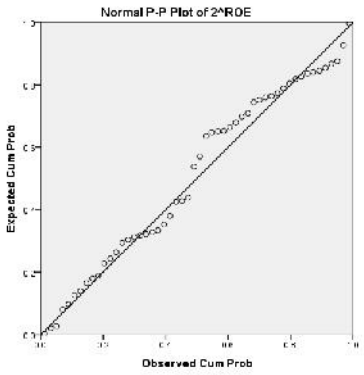


Figure xviii: Normal PP standardized residual plot of ROE and 2^{ROE} for 2013 data

APPENDIX II (Data tables)

Name of the company	M/B	LOG(M/B)	ROE	2^{ROE}	HCE	SCE	CEE	VAIC
ACADIA Pharmaceuticals Inc.	2.04	0.31	-0.86	0.55	0.09	-9.59	0.07	-9.43
Affymetrix Inc.	1.00	0.00	-0.10	0.93	1.09	0.08	0.46	1.64
Akorn, Inc.	6.99	0.84	0.35	1.28	1.88	0.47	0.38	2.73
Alnylam Pharmaceuticals, Inc.	2.73	0.44	-0.42	0.75	0.64	-0.57	0.31	0.39
Amgen Inc.	2.17	0.34	0.17	1.13	1.70	0.41	0.38	2.49
ANI Pharmaceuticals, Inc.	1.41	0.15	-1.81	0.28	0.02	-47.13	0.02	-47.09
Arena Pharmaceuticals, Inc.	7.79	0.89	-2.46	0.18	0.14	-6.35	0.08	-6.14
Biogen Inc.	4.28	0.63	0.21	1.16	1.80	0.45	0.74	2.99
China Biologic Products, Inc.	2.08	0.32	0.15	1.11	1.80	0.44	0.38	2.62
Cerus Corporation	21.54	1.33	-1.47	0.36	0.50	-0.99	0.36	-0.12
Curis, Inc.	11.14	1.05	-0.23	0.85	0.68	-0.48	0.38	0.58
DepoMed Inc.	2.43	0.39	1.10	2.14	1.74	0.42	1.02	3.18
DURECT Corporation	23.60	1.37	-2.09	0.24	0.63	-0.59	0.70	0.74
Endo International plc	2.10	0.32	0.10	1.07	1.51	0.34	0.68	2.52
Flamel Technologies SA	4.01	0.60	-0.27	0.83	0.83	-0.21	0.43	1.04
Amicus Therapeutics, Inc.	3.25	0.51	-0.94	0.52	0.30	-2.30	0.31	-1.69
Gilead Sciences Inc.	5.08	0.71	0.44	1.36	2.66	0.62	0.43	3.71
Illumina Inc.	3.57	0.55	0.08	1.05	1.53	0.35	0.43	2.32
Inovio Pharmaceuticals, Inc.	1.14	0.06	-0.33	0.80	0.39	-1.58	0.30	-0.90
Ionis Pharmaceuticals, Inc. (formerly known as Isis pharma)	3.86	0.59	-0.41	0.75	0.65	-0.54	0.24	0.35
Jazz Pharmaceuticals Public Limited Company	11.60	1.06	1.12	2.17	2.10	0.52	1.29	3.92
Luminex Corporation	3.46	0.54	0.06	1.04	1.36	0.27	0.64	2.27
Momenta Pharmaceuticals Inc.	2.23	0.35	0.59	1.51	2.79	0.64	0.70	4.13
Neurocrine Biosciences Inc.	8.10	0.91	0.95	1.93	1.80	0.44	0.56	2.80
Novavax, Inc.	2.68	0.43	-0.34	0.79	0.32	-2.15	0.28	-1.55
Oncothyreon Inc	9.24	0.97	-1.63	0.32	0.02	-40.27	0.01	-40.24
Osiris Therapeutics, Inc.	4.35	0.64	0.41	1.33	1.58	0.37	0.79	2.73
Progenics Pharmaceuticals, Inc.	3.60	0.56	0.17	1.12	1.17	0.15	1.05	2.37
Qiagen NV	1.27	0.10	0.04	1.03	1.43	0.30	0.74	2.47
Regeneron Pharmaceuticals, Inc.	12.02	1.08	-0.44	0.74	0.73	-0.37	0.36	0.72

Rigel Pharmaceuticals, Inc.	2.19	0.34	-0.43	0.74	0.07	-12.59	0.03	-12.49
SciClone Pharmaceuticals, Inc.	1.78	0.25	0.24	1.18	1.38	0.28	0.95	2.61
Shire plc	6.59	0.82	0.31	1.24	1.56	0.36	1.19	3.11
Bio-Techne Corp.	4.33	0.64	0.21	1.15	3.78	0.74	0.49	5.00
United Therapeutics Corporation	2.33	0.37	0.24	1.18	2.01	0.50	0.45	2.96
Vertex Pharmaceuticals Incorporated	11.99	1.08	0.05	1.03	1.13	0.12	0.83	2.09
Xenoport, Inc.	1.53	0.18	-0.39	0.76	0.59	-0.68	0.42	0.34
Acorda Therapeutics, Inc.	5.02	0.70	0.17	1.13	1.21	0.17	0.62	2.00
Arrowhead Research Corp.	2.83	0.45	-0.29	0.82	0.66	-0.53	0.13	0.26
Celldex Therapeutics, Inc.	1.43	0.15	-0.62	0.65	0.06	-16.05	0.04	-15.96
Genomic Health Inc.	7.07	0.85	0.08	1.06	1.09	0.09	1.26	2.44
ImmunoGen, Inc.	6.33	0.80	-0.48	0.72	0.30	-2.28	0.11	-1.86
Immunomedics Inc.	9.00	0.95	-0.44	0.74	2.36	0.58	1.79	4.73
Impax Laboratories Inc.	2.33	0.37	0.12	1.09	1.76	0.43	0.34	2.53
Ironwood Pharmaceuticals, Inc.	10.69	1.03	-0.48	0.72	0.57	-0.74	0.36	0.20
The Medicines Company	2.12	0.33	0.29	1.23	1.24	0.19	0.57	2.00
Myriad Genetics, Inc.	3.19	0.50	0.18	1.13	1.84	0.46	0.67	2.96
Mylan N.V.	2.63	0.42	0.15	1.11	2.00	0.50	0.56	3.06
Sucampo Pharmaceuticals, Inc.	5.15	0.71	-0.37	0.77	0.67	-0.49	0.23	0.41
Seattle Genetics, Inc.	8.40	0.92	-0.80	0.57	0.41	-1.46	0.23	-0.83
Spectrum Pharmaceuticals, Inc.	4.99	0.70	0.37	1.29	1.61	0.38	0.67	2.66
Sarepta Therapeutics, Inc.	3.19	0.50	-0.16	0.89	0.58	-0.72	0.97	0.84
Vanda Pharmaceuticals, Inc.	3.55	0.55	-0.28	0.83	0.78	-0.28	0.18	0.69

Table 24: 2011 Data table

Name	M/B	Log(M/B)	ROE	2^{ROE}	HCE	SCE	CEE	VAIC
ACADIA Pharmaceuticals Inc.	4.01	0.60	-0.38	0.77	0.19	-4.14	0.05	-3.90
Affymetrix Inc.	0.81	-0.09	-0.04	0.97	0.98	-0.02	0.85	1.82
Akorn, Inc.	6.36	0.80	0.20	1.15	2.24	0.55	0.56	3.35
Alnylam Pharmaceuticals, Inc.	7.16	0.85	-0.84	0.56	0.01	-74.65	0.01	-74.63
Amgen Inc.	3.42	0.53	0.23	1.17	1.81	0.45	0.39	2.66
ANI Pharmaceuticals, Inc.	1.08	0.03	-0.84	0.56	0.09	-9.96	0.06	-9.81
Arena Pharmaceuticals, Inc.	20.0	1.30	-1.62	0.33	0.43	-1.35	0.14	-0.79
Biogen Inc.	4.97	0.70	0.21	1.15	1.76	0.43	0.71	2.90
China Biologic Products, Inc.	2.22	0.35	0.27	1.21	2.62	0.62	0.45	3.68
Cerus Corporation	9.29	0.97	-1.14	0.45	0.50	-0.99	0.36	-0.13
Curis, Inc.	7.98	0.90	-0.44	0.74	0.29	-2.49	0.12	-2.08
DepoMed Inc.	4.15	0.62	0.06	1.04	0.75	-0.33	0.73	1.16
DURECT Corporation	2.56	0.41	0.81	1.76	1.53	0.34	1.25	3.12
Endo International plc	2.71	0.43	-0.49	0.71	0.76	-0.31	0.35	0.80
Flamel Technologies SA	2.48	0.40	-0.11	0.93	0.87	-0.15	0.57	1.29
Amicus Therapeutics, Inc.	1.93	0.29	-0.99	0.50	0.26	-2.78	0.17	-2.35
Gilead Sciences Inc.	5.99	0.78	0.32	1.25	2.33	0.57	0.89	3.79
Illumina Inc.	5.22	0.72	0.13	1.09	1.47	0.32	0.40	2.19
Inovio Pharmaceuticals, Inc.	2.11	0.32	-0.48	0.72	0.25	-2.96	0.26	-2.44
Ionis Pharmaceuticals, Inc. (formerly known as Isis pharma)	5.80	0.76	-0.37	0.77	0.66	-0.52	0.21	0.36
Jazz Pharmaceuticals Public Limited Company	2.75	0.44	0.44	1.36	2.99	0.67	1.12	4.77
Luminex Corporation	2.64	0.42	0.05	1.03	1.32	0.24	0.85	2.41
Momenta Pharmaceuticals Inc.	1.69	0.23	-0.15	0.90	0.58	-0.74	0.18	0.02
Neurocrine Biosciences Inc.	3.22	0.51	0.05	1.03	1.04	0.04	0.27	1.35
Novavax, Inc.	3.50	0.54	-0.43	0.74	0.24	-3.09	0.13	-2.72
Oncothyreon Inc	1.33	0.12	-0.06	0.96	0.02	-53.81	0.01	-53.78
Osiris Therapeutics, Inc.	8.24	0.92	-0.27	0.83	0.49	-1.05	0.24	-0.32
Progenics Pharmaceuticals, Inc.	2.08	0.32	-0.51	0.70	0.28	-2.52	0.18	-2.06
Qiagen NV	1.57	0.20	0.05	1.03	1.59	0.37	0.67	2.64
Regeneron Pharmaceuticals, Inc.	13.3	1.13	0.87	1.82	1.59	0.37	0.64	2.60
Rigel Pharmaceuticals, Inc.	1.96	0.29	-0.38	0.77	0.05	-20.70	0.02	-20.64
SciClone Pharmaceuticals, Inc.	1.64	0.21	0.17	1.12	1.10	0.09	0.77	1.96
Shire plc	4.54	0.66	0.21	1.16	1.41	0.29	1.01	2.71
Bio-Techne Corp.	3.91	0.59	0.18	1.13	3.57	0.72	0.42	4.71

United Therapeutics Corporation	2.47	0.39	0.30	1.23	2.20	0.54	0.51	3.25
Vertex Pharmaceuticals Incorporated	9.11	0.96	-0.12	0.92	1.03	0.03	0.62	1.69
Xenoport, Inc.	2.81	0.45	-0.30	0.81	0.61	-0.64	0.28	0.25
Acorda Therapeutics, Inc.	2.56	0.41	0.52	1.44	1.14	0.12	0.45	1.71
Albany Molecular Research Inc.	0.79	-0.10	-0.02	0.99	1.40	0.29	0.24	1.93
Celldex Therapeutics, Inc.	4.50	0.65	-0.72	0.61	0.04	-22.21	0.03	-22.14
Genomic Health Inc.	6.45	0.81	0.07	1.05	1.07	0.07	1.32	2.47
ImmunoGen, Inc.	9.81	0.99	-0.66	0.64	0.23	-3.27	0.12	-2.92
Immunomedics Inc.	5.62	0.75	0.03	1.02	0.47	-1.11	0.41	-0.23
Impax Laboratories Inc.	2.02	0.31	0.09	1.06	1.81	0.45	0.45	2.71
Ironwood Pharmaceuticals, Inc.	8.27	0.92	-0.57	0.67	0.72	-0.38	0.70	1.04
The Medicines Company	2.21	0.34	0.09	1.07	1.30	0.23	0.46	2.00
Myriad Genetics, Inc.	3.45	0.54	0.19	1.14	1.75	0.43	0.85	3.03
Mylan N.V.	3.25	0.51	0.19	1.14	1.92	0.48	0.56	2.96
Sucampo Pharmaceuticals, Inc.	4.76	0.68	0.12	1.09	1.20	0.17	0.49	1.86
Seattle Genetics, Inc.	12.2	1.09	-0.24	0.85	0.80	-0.25	0.43	0.98
Spectrum Pharmaceuticals, Inc.	2.36	0.37	0.40	1.32	1.67	0.40	0.82	2.89
Sarepta Therapeutics, Inc.	6.62	0.82	-1.56	0.34	0.58	-0.73	0.19	0.05
Vanda Pharmaceuticals, Inc.	10.5	1.02	-1.28	0.41	0.56	-0.79	0.26	0.03

Table 25: 2012 Data table

Name	M/B	Log(M/B)	ROE	2^ROE	HCE	SCE	CEE	VAIC
ACADIA Pharmaceuticals Inc.	12.62	1.10	0.28	1.22	0.03	-31.22	0.01	-31.19
Affymetrix Inc.	2.41	0.38	-0.06	0.96	1.14	0.12	-10.19	-8.93
Akorn, Inc.	9.97	1.00	0.23	1.17	2.40	0.58	1.76	4.75
Alnylam Pharmaceuticals, Inc.	13.77	1.14	-0.44	0.74	0.41	-1.44	0.21	-0.82
Amgen Inc.	3.96	0.60	0.25	1.19	1.77	0.44	-2.68	-0.47
ANI Pharmaceuticals, Inc.	5.27	0.72	0.01	1.01	1.52	0.34	0.09	1.95
Arena Pharmaceuticals, Inc.	11.47	1.06	-0.20	0.87	0.85	-0.18	1.02	1.69
Biogen Inc.	8.13	0.91	0.24	1.18	1.94	0.48	2.16	4.58
China Biologic Products, Inc.	3.32	0.52	0.25	1.19	2.85	0.65	0.64	4.14
Cerus Corporation	12.90	1.11	-1.40	0.38	0.39	-1.59	0.43	-0.77
Curis, Inc.	5.88	0.77	-0.31	0.81	0.62	-0.62	0.41	0.41
DepoMed Inc.	6.57	0.82	0.39	1.31	1.14	0.12	2.34	3.60
DURECT Corporation	7.86	0.90	-0.64	0.64	0.35	-1.87	0.32	-1.19
Endo International plc	6.09	0.78	-0.86	0.55	0.83	-0.21	0.25	0.87
Gilead Sciences Inc.	10.59	1.02	0.30	1.23	2.27	0.56	0.92	3.76
Illumina Inc.	10.28	1.01	0.09	1.06	1.29	0.23	0.52	2.04
Inovio Pharmaceuticals, Inc.	9.91	1.00	-1.52	0.35	0.50	-0.99	0.24	-0.25
Ionis Pharmaceuticals, Inc. (formerly known as Isis pharma)	11.55	1.06	-0.22	0.86	0.79	-0.27	0.19	0.71
Jazz Pharmaceuticals Public Limited Company	5.89	0.77	0.18	1.13	2.20	0.55	0.79	3.54
Luminex Corporation	3.08	0.49	0.03	1.02	1.16	0.14	0.78	2.08
Momenta Pharmaceuticals Inc.	3.13	0.50	-0.34	0.79	0.30	-2.32	0.14	-1.88
Lexicon pharmaceuticals	4.98	0.70	-0.48	0.72	0.00	-912.92	0.00	-912.92
Neurocrine Biosciences Inc.	4.86	0.69	-0.34	0.79	0.07	-13.65	0.02	-13.56
Novavax, Inc.	4.92	0.69	-0.37	0.78	0.23	-3.26	0.10	-2.93
Oncothyreon Inc	1.71	0.23	-0.50	0.71	0.01	-83.30	0.01	-83.28
Osiris Therapeutics, Inc.	17.29	1.24	0.71	1.64	0.89	-0.12	0.20	0.97

Progenics Pharmaceuticals, Inc.	3.73	0.57	-0.59	0.67	0.15	-5.81	0.09	-5.57
Qiagen NV	2.09	0.32	0.03	1.02	1.37	0.27	0.30	1.93
Regeneron Pharmaceuticals, Inc.	16.24	1.21	0.27	1.20	1.67	0.40	0.67	2.75
Rigel Pharmaceuticals, Inc.	1.12	0.05	-0.36	0.78	0.08	-10.77	0.04	-10.65
SciClone Pharmaceuticals, Inc.	1.79	0.25	0.08	1.05	1.22	0.18	0.82	2.22
Shire plc	6.75	0.83	0.15	1.11	1.80	0.44	0.77	3.01
Bio-Techne Corp.	4.85	0.69	0.16	1.12	3.35	0.70	0.37	4.43
United Therapeutics Corporation	4.52	0.66	0.15	1.11	1.47	0.32	0.49	2.28
Vertex Pharmaceuticals Incorporated	13.73	1.14	-0.38	0.77	0.33	-2.01	0.19	-1.49
Xenoport, Inc.	3.91	0.59	-0.93	0.52	0.09	-10.58	0.10	-10.39
Acorda Therapeutics, Inc.	2.80	0.45	0.04	1.03	1.16	0.13	0.47	1.76
Albany Molecular Research Inc.	1.48	0.17	0.06	1.04	1.79	0.44	0.18	2.42
Celldex Therapeutics, Inc.	13.76	1.14	-0.39	0.76	0.05	-21.16	0.01	-21.11
Genomic Health Inc.	6.21	0.79	-0.09	0.94	0.98	-0.02	1.28	2.23
ImmunoGen, Inc.	8.95	0.95	-0.71	0.61	0.37	-1.70	0.19	-1.14
Immunomedics Inc.	8.68	0.94	-0.35	0.78	1.06	0.06	0.70	1.81
Impax Laboratories Inc.	2.14	0.33	0.13	1.10	1.16	0.14	0.23	1.52
Ironwood Pharmaceuticals, Inc.	16.59	1.22	-2.99	0.13	0.10	-8.77	0.10	-8.57
The Medicines Company	2.86	0.46	0.02	1.01	1.11	0.10	0.71	1.92
Myriad Genetics, Inc.	2.54	0.41	0.22	1.16	1.78	0.44	0.74	2.95
Mylan N.V.	5.02	0.70	0.20	1.15	1.86	0.46	0.42	2.74
Sucampo Pharmaceuticals, Inc.	8.17	0.91	0.13	1.09	1.16	0.14	0.60	1.90
Seattle Genetics, Inc.	20.88	1.32	-0.27	0.83	0.83	-0.21	0.53	1.14
Spectrum Pharmaceuticals, Inc.	1.88	0.27	-0.22	0.86	0.89	-0.13	0.52	1.28
Sarepta Therapeutics, Inc.	3.11	0.49	-0.60	0.66	0.15	-5.74	0.05	-5.54
Vanda Pharmaceuticals, Inc.	8.27	0.92	-0.75	0.59	0.63	-0.59	0.23	0.26

Table 26: 2013 Data table