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Value creation during fourth industrial revolution: Use of intellectual capital by most innovative companies of the world

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ABSTRACT

This study investigates the impact that intellectual capital (IC) and value creation have on a firm's performance, in relation to the leading innovative firms in the world, at the start of the Fourth Industrial Revolution. An analysis is based on the top 100 innovative companies from different countries and sectors, as indexed by Forbes in 2016, for the period between 2011 and 2015, by using the pooled OLS regression model. The Fourth Industrial Revolution characterizes the fusion of technologies, and is blurring the boundaries between physical, digital, and biological spheres. The study reveals that capital employed efficiency and human capital efficiency have a significant positive impact on a firm's performance, whereas, the relational capital efficiency and structural capital efficiency are not related to it. Findings also suggest that relational capital efficiency is positively related to the value creation of innovative firms, while all the other mechanisms of intellectual capital and Modified Value-Added IC (MVAIC), are not associated with the value creation of innovative companies. The study advocates that innovation policies are critical, and require a rigorous review from the top management in order to meet the challenges of the Fourth Industrial Revolution, that is heavily innovation-based, and requires overwhelmingly new competencies.

1. Introduction

Intellectual capital (IC) and value creation (VC) are known to be critical determinants for organizational performance, and the innovative solutions that are offered. IC is the immaterial estimation of a business, and it has gotten wide pervasiveness since the last 10 years. The[1] Fourth Industrial Revolution is reshaping policies that pertain to innovation, for the purpose of sustainable and inclusive growth. Also, IC is an important asset for organizations' management, and plays an important role in its performance for achieving competitive advantage. It can be regarded as a shrouded incentive to accomplish competitive advantage (Bismuth et al., 2008). In this context, most of the company's value that is largely reliant on intangible assets, tend to have enlarged vibrantly, and in most cases, IC appears to be a key feature for firms' valuation issues.

The expanding significance of intellectual assets, trademarks, programming, innovative work, patents, staff aptitudes, methodology, preparation quality, and client connections convey the fact as to how information is made, held, and used to obtain economic returns. Learning that is epitomized in intellectual assets is becoming distinctly critical for the firms' growth and development. The rivalry is driving many organizations to gather intellectual assets, and utilize them successfully, in order to create gainful advancements. In this new environment that is portrayed by progressive markets in the worldwide arena, organizations should have the capacity to gain financial benefit from their intellectual assets. Policymakers, likewise, need to guarantee that the useful impacts of intellectual assets should spread all the way through the economy, especially along the lines of empowering the congregate of best practices. Difficulties in measuring intellectual capital bring new challenges at both the macro and the micro levels. At the macro level, it shows the restricted capability of the system of national accounts to provide a correct picture of investments and economic growth, and at a micro level, it deals with the limited scope for disclosing intellectual capital in the financial accounts (Bismuth et al.,

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[1] Klaus Schwab first time introduced the concept of the Fourth Industrial Revolution in 2016.

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2008).

The driving force of the Fourth Industrial Revolution is innovation – that is, experimenting with different ways to make use of a range of emerging physical, digital, and biological technologies, that transform how we produce, consume, interact, and ultimately how we meet the sustainable development goals. In order to meet the growth goals due to innovativeness, the interest in the intellectual capital has increased exponentially, because of its significance for brand value and intangible assets, as they are the drivers for the long-term business competitiveness of an organization. These two terms - brand value and intangible assets – are perceived to have a positive association with the financial and non-financial performance of the firms (Cheng et al., 2010; Marr and Roos, 2005).

The current study contributes to the ever-developing literature of IC, and the firm's performance in a particular scenario of the Fourth Industrial Revolution. Particularly, the study sheds light on the IC and VC practices of the top most innovative companies in the world, and how they contribute to the performance of these particular companies. Moreover, this study is capable of giving useful insights to investors, policymakers, managers, and the executive management of companies and regulatory bodies. To meet the opportunities and challenges of the Fourth Industrial Revolution, innovation and industrial policies can also help steer it towards sustainable and inclusive growth. Mendi et al. (2020) emphasize on the need for cooperation towards technological advancements, in order to enhance innovation and development. Moreover, Braune et al. (2020) explore the importance of Intellectual capital disclosure and governance for financial performance. This study is also important for the executive management of companies, which manage their resources for gaining competitive advantage through value addition, and value creation, so as to meet the challenges and opportunities of the Fourth Industrial Revolution.

Most of the existing studies on IC consider the developed countries for their analysis. Usually, this concept has a significant worldwide appeal, as shown in the studies conducted by (e.g. Cabrita and Bontis, 2008; Sharabati et al., 2010; Seleim et al., 2007). Most of the studies are carried out to find out the factors that make a firm worth more than its book value. Previous studies suggest that the impact of different aspects of IC on innovation is therefore, limited (Wang and Chang, 2005). The effect of IC on innovation is acknowledged extensively by (Subramaniam and Youndt, 2005), but still, there is a need for an in-depth analysis of this impact.

This study undertakes four facets of Intellectual Capital (IC), i.e., Human Capital (HC); Relational Capital (RC); Structural Capital (SC), and Capital Employed Efficiency (CEE) and the combination of these four aspects that is known as Modified Value-Added IC (MVAIC), used for value addition. Components of IC have different characteristics such as, HC alludes to the people who apply their aptitudes and capacities (Coleman, 1988), SC incorporates non-human resources, for example, techniques, databases, duplicate rights, auxiliary methods, rules, and strategies, RC incorporates the organization's associations with clients, sellers, and incorporates information on advertising channels, clients, and providers' connections, and CEE is additionally one of the parts to the IC model which incorporates the productivity of the capital. The constructs of IC have been considered as the important factors (driving factors) that determine the organization's achievement and performance.

This paper contributes to the literature in the following aspects. In the existing literature, the research is mainly focused on a specific sector or market, in order to analyze the impact of innovation strategies or value creation on the performance of the firms. Whereas, this paper analyzes the top 100 innovative firms from the "Forbes most innovative companies" list, in order to determine how the performance of such companies is enhanced by value creation, in a new industrial era. Logical reasoning for this sample is based on the fact that the most innovative company emphasizes on value creation, and in turn, their objective of enhanced performance is achieved. Thus, this paper analyzes how a competitive strategy, based on pursuing an innovation strategy, will affect performance in the transition to a new era. Last, but not the least, this study can be a pioneering study that can be used to provide a comprehensive evaluation of possible models, which may emphasize on the firms' related aspects, including performance and value creation, in a period where electronics and information technology are fused together to automate production, so as to enter the new era of the Fourth Industrial Revolution. Only those companies that can create value, most specifically intellectual value, by utilizing their physical and intellectual resources to enhance their performance, will be able to meet the challenges of the new technologically revolutionary era. Therefore, this study adds to the existing literature of innovation strategy, value creation, and intellectual capital.

The objective of this research is two-fold. Primarily, it aims to determine how innovative companies create their value, and then how that is linked with increased performance. This research also attempts to provide clarity regarding the value creation that takes place behind an innovation-driven corporate strategy, and its possessions pertaining to the organization's long-term objective to be successful in the digital revolution era, that is the start of the Fourth Industrial Revolution.

1.1. *Importance of innovation*

The term innovation is a momentous factor of organizational achievement, in addition to the competitive advantage (Rhee et al., 2010). Innovation means when an organization introduces new processes, services, or products to stir a positive change in their business. This can include improving existing methods or practices, or even starting from scratch. Ultimately, the goal is to reinvigorate the business, creating new value and boosting growth and/or productivity. Moreover, the importance of innovation is essential for pursuing long term advantages (Hamel, 1998). The innovativeness of the firm indicates towards a situation in which a company produces timely novel solutions using knowledge. Innovation ability is largely dependent upon how an organization spends its resources on the specific invention. This signifies the start of the Fourth Industrial Revolution becoming possible, because of innovation. That is to say that we investigate diverse ways to make use of physical, digital, and biological technologies that revolutionize how we produce, consume, and interact so that the path of development can be paved. This is the main reason that research on innovation is shifting towards intellectual capital (Subramaniam and Venkatraman, 2001). Hence, it is noteworthy that innovation is a key to financial development, and can be a source of a managed upper hand to firms (Schumpeter, 1983; Tushman, 1997). The main role of innovation is to acquaint change in the firms, in order to open new doors, or endeavor the current ones to do the same (Drucker, 1985). Organizations working under the current situations of worldwide rivalry, quick mechanical advances, and asset shortage must advance keeping in mind the end goal to develop, to be powerful, and even to survive in the competitive market. Accordingly, encouraging innovation remains a noteworthy test for business officials, and an important area in which scholastic research can make important contributions.

Past research on innovation has focused on the determinants of innovation (Subramanian and Nilakanta, 1996; Zmud, 1982; Nystrom et al., 2002). Therefore, the era of innovation is expected to add to a firm's adequacy and intensity, by opening new doors or by utilizing the current doors in novel ways. Roberts (2016) characterizes innovation as the advancement of thought or creation, and its change to a valuable application. The innovation-creating organizations are those that present items, administrations, or innovations that are new to the showcase (Hitt et al., 1996). Generations of inventions adhere to the modifications made into the present items, processes, administrations, or inventions that are brand new to the sector, and produce firm while the choice of invention alludes to the progressions into the embracing institution (Dewar and Dutton, 1986). Every sort of invention has probable outcomes for the firm. The adoption of innovation helps companies to

conquer inadequacies, and it may similarly help the company to adventure into new chances (Premkumar and Potter, 1995).

1.2. Innovative companies of the world

It is common knowledge that innovative firms encounter more prominent profit edges and bigger pieces of the pie, as a result of expanded client faithfulness and a restricted aggressive passage into the business sectors (Marvel and Lumpkin, 2007). Most of the innovative firms commonly contribute towards additional innovative work, as compared to the less innovative firms (Sher and Yang, 2005). Additionally, innovative companies put an incredible effort and arrangement in prototyping, which creates a lot of waste until the generation procedures are sharpened for the last item. A firm's innovativeness is the implementation of successfully novel and creative ideas. Keeping in mind the end goal to effectively improve, firms need to comprehend which asset ventures are perhaps going to lead to the reoccurrence esteem for novelty (Olson et al., 1995).

This study has taken into consideration the topmost innovative firms in the world for the year 2016, as indexed by Forbes. Forbes provides the ranking of the world's most innovative companies, on a yearly basis, and the per year ranking includes a total of 100 companies. Moreover, it includes companies from different countries and sectors. Fig. 1 shows the 2016, country-wise ranking of the most innovative companies of the world. From this figure, we can see that there are a total of 13 countries that are included in the ranking, but most of the innovative companies belong to the US. Thus, we can say that innovation is carried out in the US, most significantly better than the rest of the countries, because it encapsulates 30 companies out of a total of 100. The second-largest country that hosts innovative companies is India, claiming 13 companies in the list. Similarly, other countries like Spain, Argentina, Denmark, Indonesia, Italy, Netherlands, Norway, Poland, South Africa, Sweden, and Turkey have only one innovative company each in the list. Out of the 100 most innovative companies, a significant number of companies, as shown in Fig. 1, are from the U.S. U.S, therefore being the largest economy in terms of investments in research and development, that make it the largest country in terms of its innovative capabilities. Over the past decade, the biggest shift in global industry allocations stems from the growth of the Asian region, fueled primarily by the rise of China (Outlook, 2016).

Fig. 2 shows the sector wise innovative companies in the world. From this, we can see that the software and services are the sectors in which most of the innovation is carried out in 2016. It includes 17 companies, from different countries. The second largest sector is pharmaceuticals and health care, hosting a number of 13 and 14 companies, respectively. The telecommunication sector contains only one company. The major reason for heterogeneity observed among the sectors of innovative companies is the boom of global information technology all over the world. The global information technology (IT) market encompasses hardware, software, services, and telecommunications. Moreover, the Pharmaceuticals and health care sector is the second largest sector contributing towards innovative products and services. The factors contributing to the rapid growth of the pharmaceutical sector, as an emerging market is the patent cliff affecting several branded drugs that have been in the market for decades. The other is the shift toward the use of generic drugs in developed and developing countries, as well as the increasing availability of biosimilar drugs. Also, the changes in patterns of the diseases raise the need for more research and development in the pharma industry, which then leads to more innovation in the pharma sector.

2. Literature review

According to Klaus Schwab (2016) "The Fourth Industrial Revolution creates a world in which virtual and physical systems of manufacturing cooperate flexibly at the global level". It is the fusion of pre-existing technologies, and their interactions across the physical, digital, and biological domains that make the Fourth Industrial Revolution fundamentally different from the previous revolutions. German economist Klaus Schwab (2016) foresaw the Fourth Industrial Revolution as he stated that "We are at the beginning of a revolution that is fundamentally changing the way we live, work, and relate to one another".

In this context, innovation is a multifaceted expression that utilizes the key and operational levels of business, enveloping business procedures, items, administrations, candidate insight, business strategy, arrangement detailing, and comprehension clients. Since the primary phases of creating intellectual capital, in terms of the administration of innovation, advancement has been recognized as an important determinant of aggressiveness (Borin and Donato, 2015). The evaluation of literature has demonstrated that the results extracted from innovative procedures are hard to foresee. This is at any rate due to the reason that the effort required in building up a relationship between the measures of innovation and firm performance because innovation administration, is dependent upon the scope of many variables (Tidd et al., 2001). An underlying audit of the practice writing on innovation recognizes a crevice between the chiefs' view of innovation, and consciousness of the criteria required for fruitful innovation (Atuahene-Gima, 1996). Hirshleifer et al. (2018) empirically examined innovative originality, profitability, and stock return. Findings showed that innovative originality, and a firm's performance toward complex information, that is found in psychological studies of cognitive fluency, explain the return predictability of companies.

The connection between intellectual capital and innovation spread to strategy producers, is primarily inspired by the advancing innovation in national economies, as a wellspring of development and financial flourishment. IC is considered to be an important ingredient for organizations' future potential. Hypothetical and exact reviews demonstrate that it is one of a kind mix of diverse parts of IC, and substantial ventures

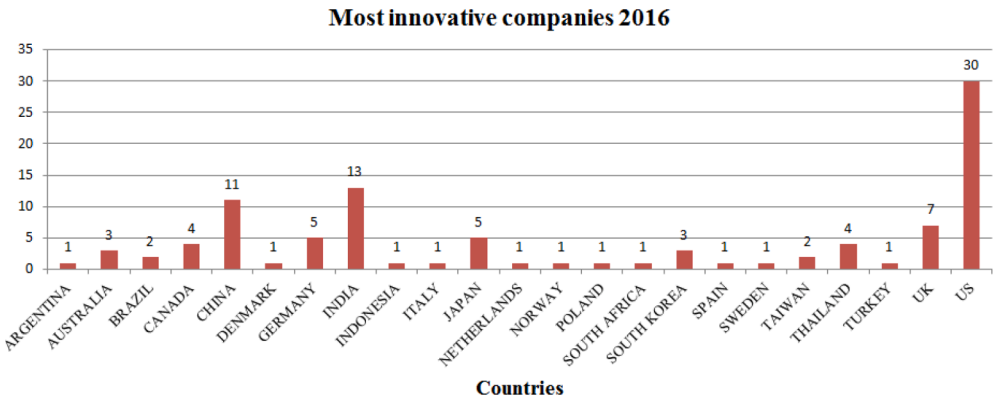

Fig. 1. Most innovative companies 2016 (Source: Forbes ranking of most innovative companies 2016).

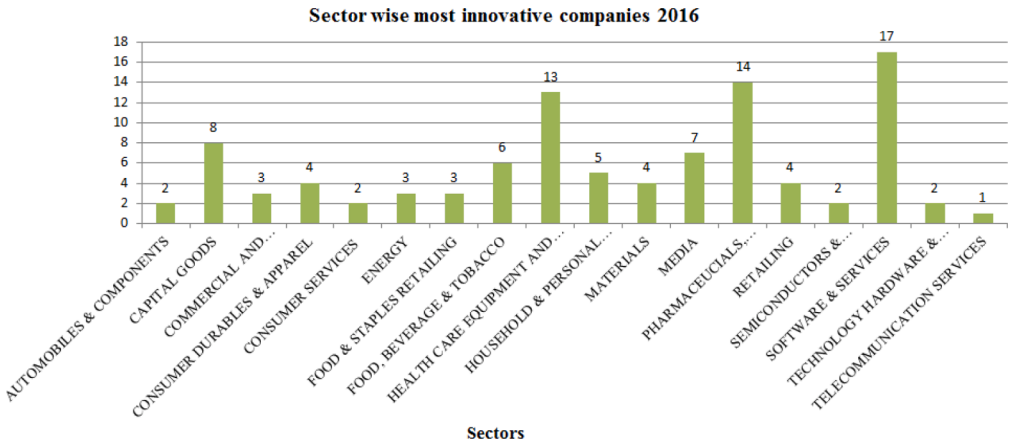

Fig. 2. Sector-wise most innovative companies 2016.

that determine an endeavor's upper hand. Moreover, experimental reviews give proof to the strong linkages and prospects among research and development, innovation, human resources, and relational capital (Zambon et al., 2006).

The expression of intellectual capital was originally established by the market analyst John Kenneth Galbraith, in the 1960s (Yitmen, 2011), and in the recent decade the phrase has grown to the extent that it has achieved ubiquity. Stewart's (1998) persuasive article recoups the expression IC after over three years, and brings it immovably on the administration and research programming maps. This term is utilized in this manner, in order to portray the dynamic effects of people's brains. This pulls in the consideration of small business specialists and analysts, and made exactly the principle stimulus for starting an inquiry into the dynamics of technological growth. IC research provides a hypothetical extension into investigating the linkages between the static idea (i.e., information stocks) and the lively thoughts (i.e., information streams) of the company's asset-based views. The asset and the view of the firm are the structures for the hypothetical advancement of capital. IC, composing additionally, gives an all-encompassing point of view of significant worth creation for the key management of the firm (Yitmen, 2011).

Human Capital speaks to this individual awareness stock of a company, represented by its workers (Bontis et al., 2002). Capital is produced by employees through their readiness, their frame of mind, and their fitness. Whilst the condition of the brain covers the area of the job of the representative, their fitness incorporates training and skills. Intellectual ability empowers humans to alter rehearsals, and to think about innovative responses for the issues at hand (Roos, 1998). Social Capital speaks to the Business's Capacities, and its internal issues to fulfill. Moreover, it integrates together programs, information frameworks, foundations, techniques, and culture. Moving on, the structural capital is the skeleton, as well as the bonding agent of a company, as it gives the tools such as managements' doctrine, culture, and processes including holding, bundling, and transferring information (Petty and Guthrie, 2000; Lim and Dallimore, 2004; Bontis et al., 2000). The RC involves an intensive understanding of market and customer preferences channels, including the connections, associations with authorities, or supplier industry affiliations. It can be distinguished as the actual and potential asset that individuals get from understanding other interpersonal drivers or organizations, with developed procedures and innovative products (Gann and Salter, 2000).

According to a survey conducted by Kirsner (2018), the main obstacles to innovation for large companies, are lack of alignment and political issues within the organization, inadaptability to change, the lack of effective change management processes, lack of effective responsiveness towards signals crucial for business success, lack of adequate budget to cater R&D requirements, and also the lack of the right strategic vision. The author stressed the need for long term commitment towards innovation in order to effectively materialize and maximize the benefits. The strategic team of the company not only has to have a clear vision of the innovation requirements of the business, but they must also ensure that these have been communicated to the grass-root level.

2.1. Innovation and performance

Srinivasan et al. (2009) empirically and conceptually examined how customer value creation (through product innovation) and customer value communication (through marketing investments) affect stock returns. Using a large-scale econometric analysis of product innovation, and associated marketing mix in the automobile industry, the results of the study revealed that pioneer innovations have a beneficial impact on stock returns. The results highlighted that the stock market returns are seven times greater, and their advertising support is nine times more effective when it comes to pioneering innovations. Other than that, Gu Feng (2005) also found that patent citation impact, and the leading Index of technology companies' innovation capacities, are linked to future earnings. The results of their study revealed that the association of earning, with the change of patent citation impact is in fact, favorable. Investors and analysts do not fully integrate improved innovation capacities for future earnings' implication into stock prices and forecasts regarding the estimated earnings. In the same context, Masso and Vahter (2007) examined the relationship between innovation and spending. They found a positive relationship with the orientation to the international market. Also, a larger propensity is found for larger firms that engage in innovative activities, and the study differentiates between the process and product innovation as well. Moreover, productivity indicates firm performance that is positively influenced by process innovation, and not by product invention.

Moving on, Salim and Sulaiman (2011) investigated the organizational learning on innovation, in addition to the impact on organizational performance, by using data of the digital survey from 320 enterprises that happen to be medium and small ICT sectors in Malaysia. These results help the firms to comprehend the relationship between functionality and creation. Results also help consultants who aid small and medium enterprises. Also, firms understand to a greater extent that it helps them to achieve their targeted strategies and better performance. Innovation isn't restricted to just big organizations, but also seeps into medium and small enterprises. Other than that, Fang et al. (2011) examined the impact of innovation and client advantage configuration plans, on the business performance. Results demonstrate that performance is greatest when companies employ configurations that require innovation or innovative assets. These need to be wide, customized and profound, the effects of which are enhanced in terms of

the business performance when the configuration approaches are used.

2.2. Innovation and technology

Barlet et al. (2000) provided some empirical evidence on how products and process innovations affect manufacturing sales and exports, by utilizing the French Ministry of Industry's Innovation survey, 1986–1990. The authors concluded that the contribution of innovative products is more in exports, as highly technological products are hard to imitate, domestics and exports sale can be increased by product improvements. In this context, the firm size has a positive effect on innovation output, only when the technological opportunity is strong. Hu and Jefferson (2002) estimated the returns to research and development (R&D) in the Chinese industry. Using a firm-level data set on innovation activity in large- and medium-sized industrial enterprises, during the year 1991–1997 in the Beijing area, authors found substantial and significant returns to R&D in the cross-section dimension. Parisi et al. (2006) found in their study that process innovations significantly impacted the Italian firms' productivity growth in the late 1990s. They also concluded that as compared to process innovations, product innovations happen to be less effective. Moreover, Koellinger (2008) empirically provided the evidence on the relationship between internet skill, invention, and the performance of a firm, by using a sample of 7302 European enterprises. Their study results show that innovations in 2003 were critical, based on internet technology. They also found in their study that innovation in the internet, or non-internet based product or processes is positively associated with sales and growth. Also, internet-based innovation firms grow more than those which were non-internet based.

Further depth in the literature shows that Eisdorfer and Hsu (2011) analyze the association between technology, competition and corporate bankruptcy. They conclude that firms' technology-driven industries have a real risk of failure, especially if they do not keep pace with the recent innovations. Inefficient and reduced productivity could be because of a decrease in demand, and market share, so firms with highly technological industries should invest more on innovations. In the same stride, Nosheen et al. (2016) determined in their study that innovation impacts the capital structure decision and performance. They also indicated that previous studies have been based on single country samples. So, to raise a new aspect, they utilized the topmost innovative companies in the world. By using international firm's data, they concluded that it is worthwhile to consider for the innovation strategy by the firms, for gaining the utmost benefits with country associated characteristics.

3. Conceptual framework

The conceptual framework of this study, presented in Figs. 3–5, comprises of three models to test the hypothesis of the study. The current study presents a conceptual framework based on the methodologies used

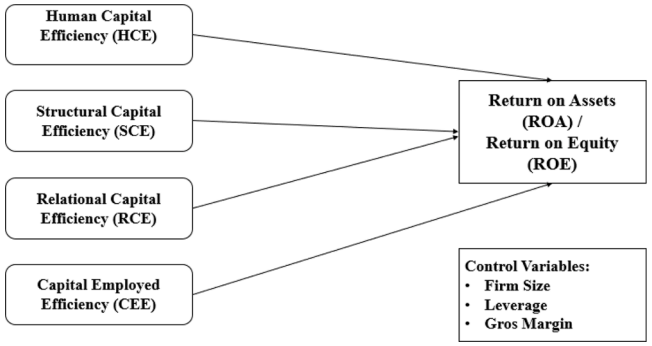

Fig. 3. Model 1 of conceptual framework.

in the literature. In this regard, (Pulic, 2000; Mavridis, 2004; Wu et al., 2008; Maditinos et al., 2011; Mehralian et al., 2012; Al-Musali, and Ku Ismail, 2016; Díez et al., 2010) examined the association among IC, VC and firms performance. Moreover, previous researches on IC and performance of the firms have been conducted in countries like South Africa, Taiwan, and China (Firer and Williams, 2003; Chen et al., 2005; Chu et al., 2011). These studies have found different results regarding intellectual capital and performance. For example, research shown by (Firer and Williams, 2003; Chen et al., 2005 find evidence that do not support the association between IC and performance. Furthermore, studies investigated by (Mehralian et al., 2012; Kamath, 2008) has found a positive linkage between IC and firms' performance. In the current study, in order to determine the impact of IC and VC on the firms' performance of the most innovative firms in the world, the following hypotheses have been proposed.

3.1. Intellectual capital and performance

The connection between IC and the firms' performance has been analyzed experimentally as well as theoretically, and IC is considered as a value driver for the company's performance (Stewart, 1998). The individual components of IC have been studied by various researchers such as, (Mehralian et al., 2012; Kamath, 2008; Firer and Williams, 2003; Chu et al., 2010). These studies have found a positive influence of HCE, CEE, and SCE, on the performance. Also, there are a number of variables for firms performance such as ROE, ROA, sales growth (SG), market to book ratio (M/B), that have been used by researchers i.e. (Clarke et al., 2011; Firer and Williams, 2003). Therefore, the hypotheses are:

H_1. There is a positive relationship between IC and the firm's performance of the most innovative companies of the world.

H_{1a}. *There is a positive relationship between HCE and the firm's performance of the most innovative companies of the world.*

H_{1b}. *There is a positive relationship between RCE and the firm's performance of the most innovative companies of the world.*

H_{1c}. *There is a positive relationship between SCE and the firm's performance of the most innovative companies of the world.*

H_{1d}. *There is a positive relationship between CEE and the firm's performance of the most innovative companies of the world.*

3.2. Value creation and intellectual capital

The wealth of the modern economy no longer depends on only physical assets, but on the contrary, it depends on intangible assets. Therefore, successful companies realize that investing in IC is essential to their ability to create high value products and services. From the result of the pioneer study, it is well perceived that intellectual capital is the lever for organizations, so as to acquire a competitive advantage and sustainable performance (Edvinsson and Sullivan, 1996; Ross and Ross, 1997; Stewart, 1995). The second hypothesis consists of empirically investigating the influence of IC on the VC, where IC is considered to be a value driver for the firms, and helps in achieving a competitive advantage. Thus, the hypothesis formed are;

H_2. There is a positive relationship between VC and IC.

H_{2a}. *There is a positive relationship between HCE and VC.*

H_{2b}. *There is a positive relationship between RCE and VC.*

H_{2c}. *There is a positive relationship between CEE and VC.*

H_{2d}. *There is a positive relationship between SCE and VC.*

3.3. Value addition, value creation and performance

The third hypothesis is to test the influence of Value Addition (VA) and Value Creation (VC) on the firm's financial performance. This hypothesis is supported by studies that have been conducted by (Vishnu and Gupta, 2014; Peng et al., 2007; Schiuma and Lerro, 2008). Hence, the following hypothesis is tested in the current study:

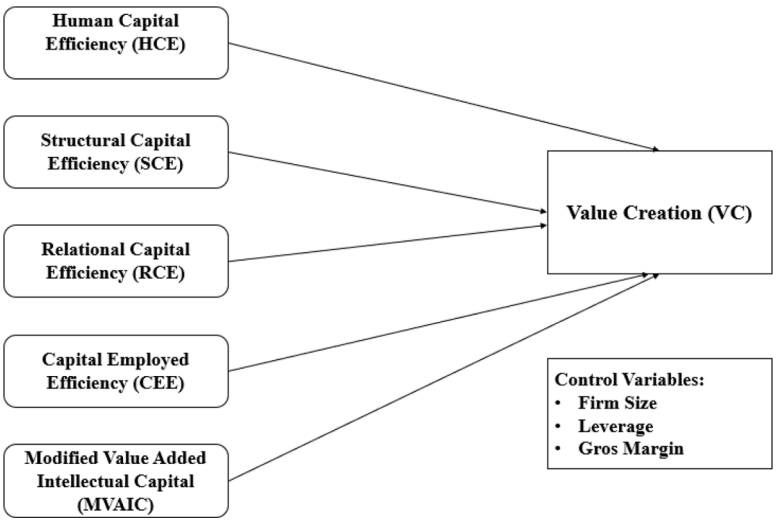

Fig. 4. Model 2 of conceptual framework.

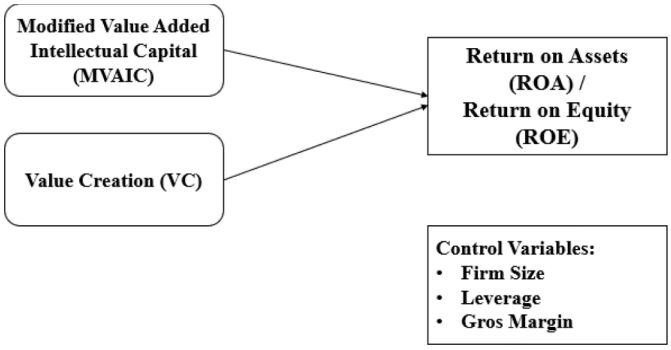

Fig. 5. Model 3 of conceptual framework.

H_3. There is a positive relationship between VA and performance.
H_{3a}. There is a positive relationship between VC and performance.

4. Methodology

4.1. Target population

The target population of the study are the topmost innovative companies in the world, as indexed by Forbes, for the year 2016. There are a total of 100 companies in ranking from different countries and different sectors. The concept of the Fourth Industrial Revolution was coined in 2016, by Klaus Schwab, so the data set used comprises of the 2016 ranking that has been published by Forbes. For the purpose of the study, the past five years' performance of the particular companies in question has been evaluated, in order to investigate whether the firms' innovation investment has value addition capacity, and its impact on firm's performance is also examined.

4.2. Data and methods

The current study uses secondary data from the annual financial statements of the sample firms, for the years 2011–2015. The sample data covers 100 companies, and comprises of the 2016 ranking published by Forbes. The annual reports have been downloaded from the company's websites. Also, the statistical techniques used in this study are the descriptive statistics, correlation matrix, and the Pooled OLS regression model.

We have applied the panel data models for the data analysis. According to Baltagi (2008), the panel data refers to the pooling of observations on the cross-sections. With the panel data, the usual OLS standard errors are incorrect, unless there is no cluster effect, and thus, the robust standard errors that allow cluster correlation and heteroscedasticity should be used (Figures, Wooldridge, 2012). The standard errors clustered by a firm are unbiased, and produce correctly sized confidence intervals regardless of the firm's effect being permanent or temporary.

The Pooled OLS regression model is then run to test the hypothesis. In the Pooled OLS regression, we pool all the observations together, and run the OLS model. We also assume that there is unobserved heterogeneity across the individuals. One major problem often occurring in the pooled OLS model is the serial correlation. The Durbin Watson Stat shows that there is no autocorrelation or serial correlation in the model, thus the pooled OLS is appropriate for our analysis. For this, in order to get the accuracy and the correct results, multiple regression assumptions are tested and satisfied.

In an economic model, endogeneity is observed when an explanatory variable (independent) with the residuals is correlated (Ullah et al., 2020, 2018). In the literature pertaining to IC and the firm's performance, the endogeneity comes when the dependent variable i.e., firm's performance is correlated with the error term. This problem is often times ignored by researchers i.e., (Thiagarajan and Baul 2014; Kamath, 2008; Ulum et al., 2014) and doing so precludes making the policy recommendations that may vary case to case. The model of MVAIC, as proposed by (Ulum et at., 2014), use the Pooled OLS method, by placing the value addition as a dependent variable, and each component of intellectual (HC, SC, RC and CE) as an independent variable, and observes no problem of endogeneity. Kamath (2008) also applies the same methodology.

Thus, our model can be represented as:

$$Y_{it=}\ \alpha_{i+}\ \beta X_{it} + \ \varepsilon_{it} \tag{1}$$

As, Y is the responding variable of this study for the cross-section unit i or entity, at t time period, and α_i is the constant term. X_{it} is the regressor variable with a coefficient β and ε_{it} as error term.

Thus, the operational model of this study is as follows:

$$ROA_{it} = \beta_0 + (HCE_{it})\beta_1 + (RCE_{it})\beta_2 + (CEE_{it})\beta_3 + (SCE_{it})\beta_4 + (LSIZE_{it})\ \beta_5 + (LEV_{it})\beta_6 + (GM_{it})\beta_7 + \mu_{it} \tag{2}$$

$$ROE_{it} = \beta_0 + (HCE_{it})\beta_1 + (RCE_{it})\beta_2 + (CEE_{it})\beta_3 + (SCE_{it})\beta_4 + (LSIZE_{it})\ \beta_5 + (LEV_{it})\beta_6 + (GM_{it})\beta_7 + \mu_{it} \tag{3}$$

$$VC_{it} = \beta_0 + (HCE_{it})\beta_1 + (RCE_{it})\beta_2 + (CEE_{it})\beta_3 + (SCE_{it})\beta_4 + (LSIZE_{it})\beta_5 + (LEV_{it})\beta_6 + (GM_{it})\beta_7 + \mu_{it} \quad (4)$$

$$VC_{it} = \beta_0 + (MVAIC_{it})\beta_1 + (LSIZE_{it})\beta_2 + (LEV_{it})\beta_3 + (GM_{it})\beta_4 + \mu_{it} \quad (5)$$

$$ROA_{it} = \beta_0 + (MVAIC_{it})\beta_1 + (VC_{it})\beta_2 + (LSIZE_{it})\beta_3 + (LEV_{it})\beta_4 + (GM_{it})\beta_5 + \mu_{it} \quad (6)$$

$$ROE_{it} = \beta_0 + (MVAIC_{it})\beta_1 + (VC_{it})\beta_2 + (LSIZE_{it})\beta_3 + (LEV_{it})\beta_4 + (GM_{it})\beta_5 + \mu_{it} \quad (7)$$

The first model of this study includes Eq. (2) and 3, where ROA and ROE is the dependent variable, and the individual mechanisms of IC are independent. The control variables that are used in this model are LSIZE, LEV and GM. Model 2 includes Eqs. (4) and 5, where VC is the value creation, and is the dependent variable, and the independent variables include HCE, RCE, CEE, SCE and MVAIC, and the control variables are LSIZE, LEV and GM. The model 3 includes Eq. (6) and 7, these are for testing the impact of MVAIC, and the VC on ROA and ROE by controlling LSIZE, LEV and GM.

4.3. Operationalization of variables used

The study mainly emphasis on the modified value-added intellectual capital (MVAIC) for value addition. This is derived by adding all the components of the IC. In this context, Ulum et al., (2014) derived the model for MVAIC, that is given in Fig. 6, below.

The IC components considered are human, relational, structural, and then these mechanisms form the Intellectual Capital Efficiency (ICE), and then by combining ICE with capital employed efficiency we get the MVAIC. Table 1 explains all the dependent and independent variables measurements.

Table 1
Measurement of Dependent and Independent Variables.

Variables	Abbreviations	Variable measurement
Value creation	VC	VC is the percentage of growth in sales in 5 years, from 2011 to 2015.
Human capital efficiency	HCE	Value added = VA = operating profit + salaries and wages + depreciation + amortization. HC shows the total salaries and wages. Thus HCE = VA/HC
Relational capital efficiency	RCE	Relational capital (RC) shows the marketing costs. Thus RCE = RC/VA
Structural capital efficiency	SCE	Structural capital (SC) = VA - HC. Thus SCE = SC/VA
Capital employed efficiency	CEE	Capital employed (CE) = Total assets - current liabilities. Thus CEE = VA/CE
Modified value added intellectual capital	MVAIC	MVAIC = HCE + SCE + RCE + CEE
Return on assets	ROA	ROA = Net income / Total assets
Return on equity	ROE	ROE = Net income / Total equity
Natural log of company size	LSIZE	Size shows the total assets of the company.
Leverage	LEV	Leverage is calculated by dividing long term debt with the total assets of a company.
Gross margin	GM	GM = Total sales - cost of goods sold / Total sales

LSIZE, LEV and GM are the control variables. These variables have been frequently used in studies such as (Maji and Goswami, 2016; Firer and Stainbank, 2003).

Table 2
Summary of statistics.

Variables	Mean	Std. Dev	Range	Minimum	Maximum	Count
LSIZE	22	2	12	17	29	500
HCE	2.64	8.86	228.16	−61.32	166.84	500
RCE	0.33	1.56	30.07	−17.92	12.15	500
CEE	0.91	3.59	91.67	−28.14	63.52	500
SCE	0.56	4.94	141.41	−39.52	101.89	500
MVAIC	4.43	10.41	229.44	−60.82	168.62	500
GM	52.28	23.04	140.20	7.80	148.00	500
ROA	11.54	22.58	283.59	−48.13	235.46	500
LEV	3.20	5.23	53.36	0.48	53.84	500
ROE	24.22	71.73	1423.19	−518.21	904.98	500
VC	18.84	21.33	255.49	−22.17	233.32	500

5. Results and discussions

5.1. Summary of statistics

Table 2 shows the summary statistics of all the variables for the period ranging from 2011 to 15. The average size of the firms is 22, with a range of 12 and a standard deviation of 2. Also, the average HCE is 2.64, with a range and standard deviation of 228 and 8.86. The mean RCE is 0.33, with a range of 30.07, and a standard deviation of 1.56. The average CEE is 0.91, with a range and standard deviation of 91.67 and 3.59. The mean SCE is 0.56, with a range and standard deviation of 141.41 and 4.94, respectively. The MVAIC have large variations with the standard deviation of 10.41, and a range of 229.44, and its average value is 4.43. The maximum value of ROA is 235, and the minimum is – 48,

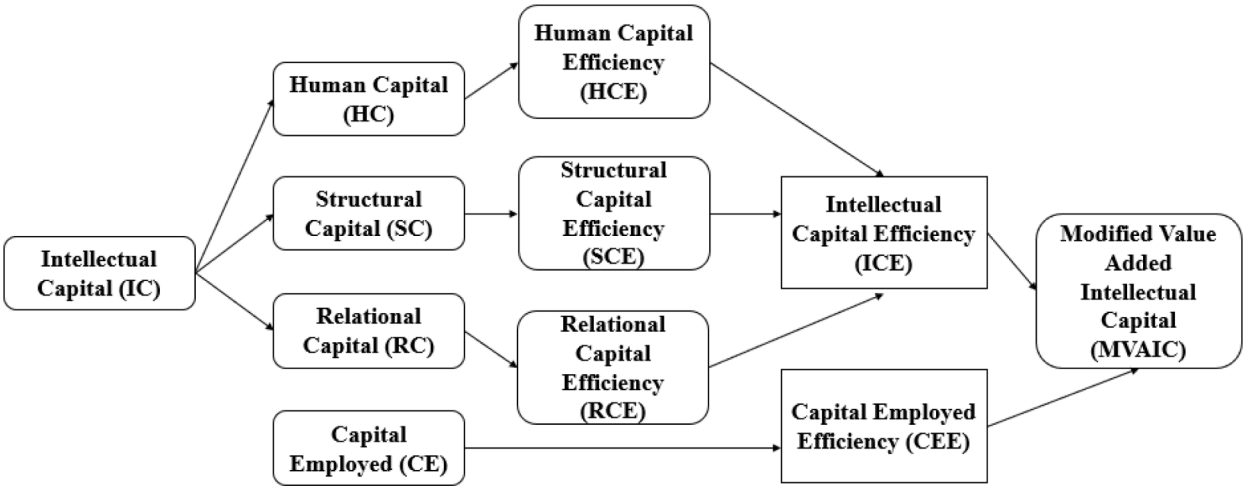

Fig. 6. Framework of M-VAIC.

due to losses, whereas, the average performance is 11.54. The average ROE is 24.22, with a range and standard deviation of 1423 and 71.73. The average VC is 18.84, with a range a standard deviation of 255.49 and 21.33, respectively.

5.2. Pearson correlation

Table 3 displays the results of the Pearson Correlation Matrix, and it indicates that all the variables used in this study are not correlated with each other as much, so there is no problem of multicollinearity among these variables.

5.3. Results and discussion

Tables 4 and 5 summarize the results of the pooled OLS regression. To test the hypothesis H_1, and H_{1a}-H_{1d} (Model 1), we regress the HCE, RCE, CEE, and SCE on ROA and ROE, by controlling the LSIZE, LEV, and GM. The results show that the HCE is significant at 1%, with ROA, and at 5% with ROE, and positively relates to both the ROA and ROE. The SCE is likewise found to be significant with both the ROA and ROE, and positively relates to both. The size and gross margin are insignificant, while the leverage is significant and has a negative impact on both the ROA and ROE. This will lead to accepting the hypothesis H_{1a} and H_{1d}. The findings suggest that HCE and CEE are associated positively with the firms performance and these results are consistent with the findings of (Mehralian et al., 2012; Kamath, 2008; Firer and Williams, 2003). The empirical analysis also shows that the HCE and CEE have a major impact on the profitability and productivity of the firms, over the period of the study.

In order to test the second hypothesis, we need to test the impact of IC on VC. For this purpose, we use model 2, in which we regress HCE, RCE, CEE, SCE, and MVAIC on the VC. The results describe that only RCE is statistically significant at 5%, and positively associated with VC. This leads us to accepting the hypothesis H_{2b}. Moreover, HCE, RCE, CEE and SCE show an insignificant relationship. Moreover, MVAIC is also insignificant, with the value creation by firms. The regression results also show that the SC is not related with the performance of the innovative companies. The absence of a relationship with the market valuation demonstrates that investors usually do not focus on SC, when they assess the firms' value. These results are consistent with the findings of Mehralian et al. (2012). Moreover, our study could not confirm the results of Cabrita and Bontis (2008), who argued regarding the importance of SC, and explained that if a company has efficient structural capital which includes systems, database, trademarks and patients etc. it can achieve optimal performance. Also, Malhotra (2003) explains that the reason for IC not having a significant relationship with value is that the companies, for their valuation, focus on the tangible assets instead of the intangible assets Thus, it seems absolutely logical for the VAIC studies to fail when trying to establish a relationship between IC and the company value.

Finally, in order to test the H_3, we use model 3, in which we regress the MVAIC and VC on the ROA and ROE. Results reveal that MVAIC is significant at 1%, and is associated positively with the performance, whereas, VC is also significant at 1%, but negatively relates to performance. This leads us to accepting H_3 and H_{3a}. This study also suggests that the relational capital is significant with the value creation of the firms; this shows us evidence that innovative companies create value by spending more on their relational capital. Furthermore, these results are also consistent with the findings of Shakina and Barajas (2013), as they also find a significant and positive association between RC and VC by firms, in the long-run. Other parts of IC and MVAIC are not related by the VC. Furthermore, the results of our study also show a positive association between MVAIC and firms performance, and these findings are consistent with (Bontis et al., 2000; Zéghal and Maaloul, 2010; Ulum et al., 2014). These results imply that firms should focus on their intangible (Knowledge based), and also develop the structural capital that ultimately yields a sustainable competitive advantage. This advantage will lead itself to improved performance.

Table 4
Pooled OLS Regression Model 1 Results.

	Model 1: Dependent Variables = ROA, ROE			
	ROA		ROE	
Independent Variables	Coefficient	T-Value	Coefficient	T-Value
Constant	5.940	0.740	82.782**	2.450
HCE	0.3712***	4.280	0.873 **	2.400
RCE	0.067	0.100	−3.023	−1.130
CEE	4.1875***	19.820	3.252 ***	3.670
SCE	0.090	0.450	−0.503	−0.590
LSIZE	0.102	0.290	−2.626*	−1.790
LEV	−0.4982***	−3.470	−1.918***	−3.180
GM	0.002	0.050	0.029	0.210
Observations	500		500	
Prob > *F*	0.000		0.000	
R-squared	0.463		0.063	
Ajd R-squared	0.455		0.050	

Note:.
*** Statistically significant at%.
** Statistically significant at%.
* Statistically significant at 10%.

6. Conclusion and policy implications

This study is an endeavor to explore the relationship among IC, VC, and the performance of the world's most innovative companies. With the beginning of the Fourth Industrial Revolution, and the increasing speed at which products and entire markets are changing, operational excellence has become more business-critical for all the organizations than ever before. In a world in which progress is a continuous process, development models, and practices based on update-and-maintenance cycles of months, or even years have become inadequate. Hence, the Fourth Industrial Revolution demands a paradigm shift in terms of

Table 3
Pearson Correlation Matrix.

	HCE	RCE	CEE	SCE	MVAIC	LNSIZE	GM	LEV	ROA	ROE	VC
HCE	1	—	—	—	—	—	—	—	—	—	—
RCE	−0.007	1	—	—	—	—	—	—	—	—	—
CEE	.010	−0.033	1	—	—	—	—	—	—	—	—
SCE	.004	−0.661**	−0.004	1	—	—	—	—	—	—	—
MVAIC	.856**	−0.181**	.347**	.377**	1	—	—	—	—	—	—
LNSIZE	.236**	.011	−0.137**	−0.022	.145**	1	—	—	—	—	—
GM	.008	.026	.058	−0.032	.015	−0.095*	1	—	—	—	—
LEV	.013	.054	.101*	−0.027	.041	−0.024	.072	1	—	—	—
ROA	.153**	−0.038	.654**	.018	.359**	−0.044	.031	−0.047	1	—	—
ROE	.089*	−0.057	.164**	.014	.130**	−0.076	.017	−0.122**	.604**	1	—
VC	.037	.153**	−0.008	−0.103*	.002	−0.056	.034	.047	−0.106*	−0.311**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Table 5
Pooled OLS Regression Model 2 and 3 Results.

Model 2			Model 3			
Dependent Variables	VC		ROA		ROE	
Independent variables	Coefficient	T-Value	Coefficient	T-Value	Coefficient	T-Value
Constant	31.20***	3.050	33.003***	3.340	123.397***	3.890
HCE	0.129	1.290	—	—	—	—
RCE	2.004**	2.340	—	—	—	—
CEE	−0.109	−0.866	—	—	—	—
SCE	−0.027	−0.566	—	—	—	—
LSIZE	−0.670	−1.110	−1.005**	−2.480	−3.739***	−2.740
LEV	0.150	0.122	−0.264	−1.470	−1.618***	−2.820
GM	0.020	0.138	0.023	0.580	0.070	0.530
MVAIC	0.017	0.162	0.8164***	9.000	1.049 ***	3.610
VC	—	—	−0.1174***	−2.680	−1.054***	−7.500
Observations	500		500		500	
Prob > *F*	0.000		0.000		0.000	
R-squared	0.032		0.155		0.141	
Ajd R-squared	0.018		0.147		0.132	

Note:.
*** Statistically significant at 1%.
** Statistically significant at 5%.
* Statistically significant at 10%.

bringing new products, technologies, and solutions to the market, in such a way as to enable them to keep pace with the rising expectations.

The findings of the research suggest that HCE and CEE are associated positively with firms' performance, in the context of the most innovative companies in the world. The regression results also show that SC is not related to the performance of innovative companies. The absence of a relationship with the market valuation demonstrates that investors don't focus on SC when they assess a firms' value. If a company has efficient structural capital, which includes systems, databases, trademarks, and patients, etc. it can achieve optimal performance. Therefore, in order to utilize the potential of the fourth industrial revolution, there is a need to transform the innovation process. Now the companies should ideally have to identify a domain, or technology-specific issues and concerns that can be replicated across sites or domains in order to revolutionize whole industries over time.

This study also suggests that relational capital is significant with the value creation of the firms. This shows the evidence that innovative companies create value by spending more on their relational capital. Other parts of IC and MVAIC are not related by the VC of the most innovative companies. Furthermore, the results of our study show a positive association between MVAIC and the firms' performance. Moreover, a negative relationship between the VC and the firm's performance has also been observed. This might be because the sample firms are from different countries all over the world, and their focus might be on innovation and value creation. This study puts forth a major contribution towards literature, that utilizes the international sample of innovative companies from all over the world, while extant studies focus on a single county sample. Therefore, this study provides a new contribution into intellectual capital and value creation, at the advent of an industrially revolutionary era. If a company has efficient structural capital which includes systems, databases, trademarks, and patients, etc. it is ready to meet the challenges of the Fourth Industrial Revolution.

Technological uncertainty in the transformation caused by the fourth industrial revolution is dominant. This holds for the economic and firm policy, as well as for the decisions on the financial markets. In this regard, economic policy and innovation policy need an open (future-oriented) design, and instruments focusing on entrepreneurship will become the most critical, in what is called the experimentally organized economy. The Fourth Industrial Revolution is heavily innovation-based, and requires overwhelmingly new competencies. Therefore, innovation policies are of utmost importance, and require a rigorous review from the top management.

7. Limitations and future research

This study has some limitations, such as this study uses a sample period of 5 years and a larger sample might have given more accurate results. Also, the IC relates to the firm's performance in the most current years, as compared with the previous years. Secondly, this study uses an international sample from all over the world, and that too from different sectors. Other than that, the results of this study might not apply to a specific country, and a specific sector. Future researchers may select a sample of the countries, in which the most innovative companies from the world are included, such as those from US and India, and determine the factors that can significantly relate with value addition, value creation, and performance of the firms.

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