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An entropy-based analysis of financial competitiveness of Nordic manufacturing firms

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Abstract

Financial competitiveness is an essential part of the health and growth of firms. However, it is a relatively new phenomenon and is not yet well-researched. In this regard, the current study investigates whether the financial competitiveness of Nordic manufacturing firms is affected by stock market performance, financial risk, and corporate governance indicators. Thus, the author has three aims in mind. First, to form an understanding of the phenomena of financial competitiveness. Second, to establish factors affecting financial competitiveness. Third, to test and improve an existing model of evaluating financial competitiveness through entropy.

A quantitative approach shaped the research methodology. The secondary data was accumulated across four accounting phenomena: financial performance, corporate governance, stock market performance, and financial risk exposure. The total sample size extended to 513 firm-year observations from 2013-2018 across the 96 publicly traded manufacturing firms of Finland, Sweden, Norway, and Denmark. The author obtained the stock market data from Nasdaq Stockholm, Oslo Stock Exchange, Nasdaq Copenhagen, and Nasdaq OMX Helsinki. The data related to the accounting and corporate governance variables have been extracted from the sample firms' annual reports. The present study applies the entropy method to the sample to evaluate financial competitiveness at the firm-level. The sample has been further analyzed through ordinary least squares (OLS) multivariate linear regression (MLR) method and principal component analysis (PCA).

By understanding the phenomena of financial competitiveness, the author analytically explored its determinants. Additionally, the author's understanding of financial competitiveness enabled him to improve the existing entropy-based method of evaluating financial competitiveness. Further statistical analysis shows that various performance indicators play an essential role in enhancing firms' financial competitiveness in the manufacturing sector. Moreover, the limitations of the current research were discussed, and recommendations for further research were given.

Keywords/tags (subjects)

Financial competitiveness, entropy, Nordic, manufacturing, corporate governance.

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1 Introduction

The purpose of the following chapter is to introduce the research topic of the present study. This section describes the motivation for undertaking the research and the background of the topic. Furthermore, it presents the research objective and questions and explains the structure of this research.

1.1 Research motivation

The Nordic region comprises economies with low wealth inequality, extensive welfare plans, and high health and education standards, among other things. The socio-economic indicators of four Nordic countries, including Finland, Norway, Sweden, and Denmark, are among the world's best. Moreover, the countries consistently rank in or at the tops of the international innovation and competitiveness ranking; for example, the most comprehensive assessment of economic competitiveness worldwide, Global Competitiveness Report (Schwab 2019).

The report (ibid.) defines economic competitiveness as "the set of institutions, policies, and factors that determine the level of productivity of an economy, which in turn sets a level of prosperity that the economy can achieve." In line with the definition, the report presents Global Competitiveness Index (GCI) in the form of the annual competitiveness score. It is calculated based on three determining components: technology, public institutions, and macroeconomic environment (ibid.). The report series remains the most comprehensive assessment of economic competitiveness worldwide.

Figure 1 shows the development of Nordic countries' competitiveness concerning other nations from 2009-2018. The figure shows Nordic economies consistently losing their ranks over the years: Finland from ranking 6th to 10th; Sweden from ranking 4th to 7th; Denmark with the most significant decline in rank from 3rd to 12th; Norway, in contrast, gained four positions over the observed period – 15th to 11th. Figure 2 provides further insight into the problem, depicting the Global Competitiveness Index stagnating over the years for the Nordic economies, staying in the range of 5.10 to 5.70 points. A simplistic observation is that while being at the top of the index, Nordic countries are stagnating and, without action in technology, public institutions, and macroeconomic environment, risk harming competitiveness further. The situation calls for examining competitiveness from multiple directions.

Figure 1. GCI rank. (adapted from Schwab 2019)

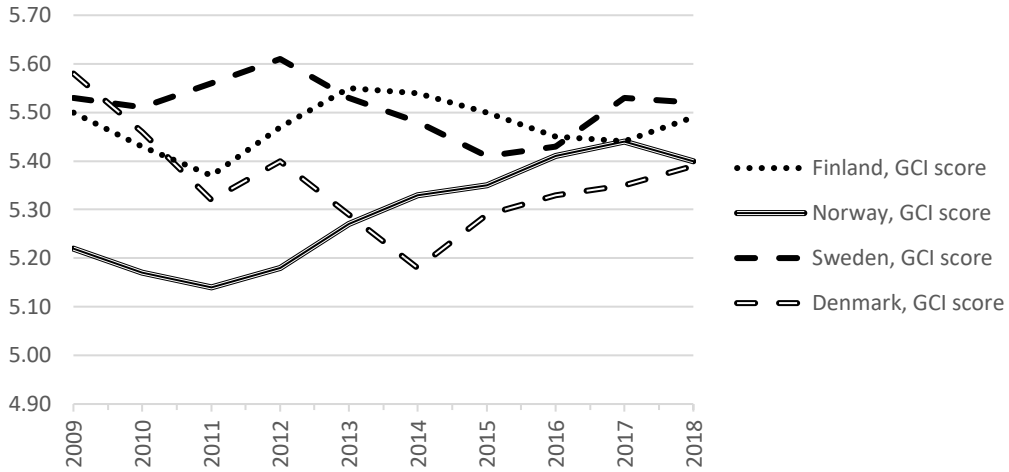

Figure 2. GCI score (adapted from Schwab 2019)

The obstacle possibly transpires from the same socio-economic successes and accomplishments, which are not free of cost. For example, Nordic countries are amongst the high cost of living countries globally, and coincidentally, the unit cost of production in Nordic countries is high. However, with the advent of several countries having lower production cost in the international markets, the Nordic manufacturing sector's cost competitiveness has been adversely affected. (Nordic Council of Ministers 2015; Solberg 2014; De Molli 2019.)

Porter (1990) defines a country's competitiveness as "the ability of a country's firm to compete in the international markets while simultaneously expanding the prosperity and living standards of citizens." From this perspective, the Global Competitiveness Report indicates a country's capacity to create competitive support for firms, determining their ability to compete in the international

markets. In this regard, the current study chose the manufacturing sector's firms for further analysis.

1.2 Nordic manufacturing sector

The present study has examined the Nordic manufacturing sector as it has been historically the driver of economic growth, employment, and healthy trade balances for the Nordic economies. However, it has undergone dramatic changes over the past two decades. The term "deindustrialization" or "erosion of manufacturing" is often used to describe the situation where thousands of jobs are being lost annually in the Nordic manufacturing sector. The region is going through a productivity decline. (Solberg 2014.)

In many ways, the problem of the falling competitiveness of the Nordic manufacturing sector is unique. For example, constrained by strict labor requirements, among other factors, the manufacturing sector resorted to the accelerated adoption of automation technologies across the board, and these technologies have been intrinsically displacing the labor (Alsén, Colotla, Daniels, Kristoffersen, & Vanne 2013). Another distinguishing fact about the Nordic manufacturing sector is its reliance on exports. Unlike larger markets, for example, the US or Germany, Nordic economies do not have sizeable domestic markets ready to consume the manufacturing output (ibid.). Therefore, the Nordic manufacturing sector operates in excess supply settings.

On the other hand, demand for manufactured goods, at the global level, has been shifting continuously from the western economies to Asia, in particular. Therefore, another phenomenon that the Nordic manufacturing sector opens to is demand deficiency. Consequently, the Nordic manufacturing sector has witnessed reduced cost competitiveness and offshore shift of manufacturing facilities (ibid.). Nordic trade statistics from 2008-2018 also reflect manufacturing migration, as shown in figure 3. For example, at the beginning of the observation period, Sweden had annual trade surpluses in products exports of 2.9 percent, which turned to a scarcity of -0.8 percent. Finland and Denmark have seen a similar decline, while Norway has experienced the most dramatic decline of almost 50 percent.

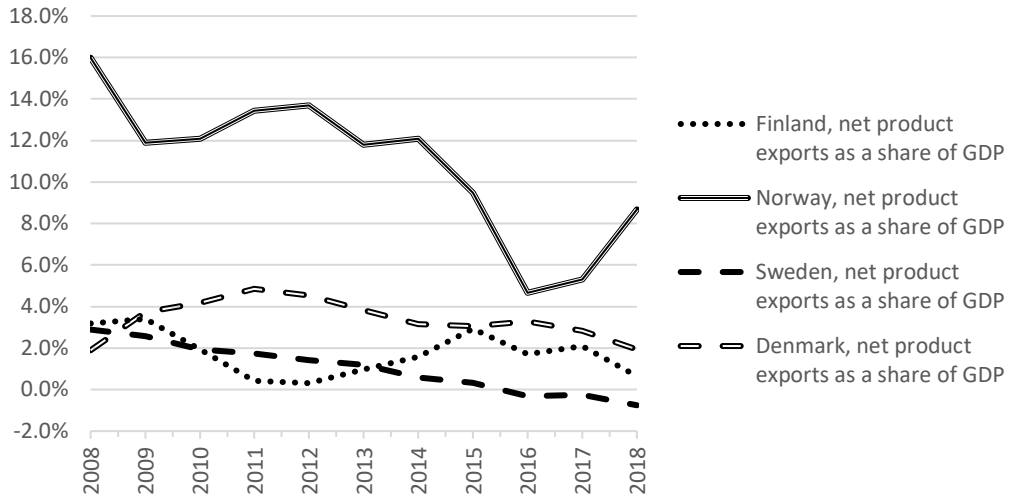

Figure 3. Net product export (% of GDP) (adapted from OECD website)

In their study, Alsén and others (2013) observed that manufactured goods net export as a share of GDP declined from 1991 to 2011, with Norway being a significant net importer. Manufacturing's share in Nordic GDP from 1980 to 2010 shrank from around 20 to 25 percent to about 15 percent (ibid.). The current research continues those observations with value-added manufacturing as a GDP share indicator for 1980-2019, as shown in figure 4. It reveals the same story of a decline in Nordic manufacturing. For example, value-added manufacturing as a share in Finland and Sweden's GDP fell from 24 percent and 21 percent at the beginning of the observation to 15 percent and 13 percent at the end of the observation, respectively. Furthermore, Denmark showed the smallest decline

from 16 percent to 13 percent, while Norway showed the greatest decline of over 50 percent from 13 percent to 6 percent.

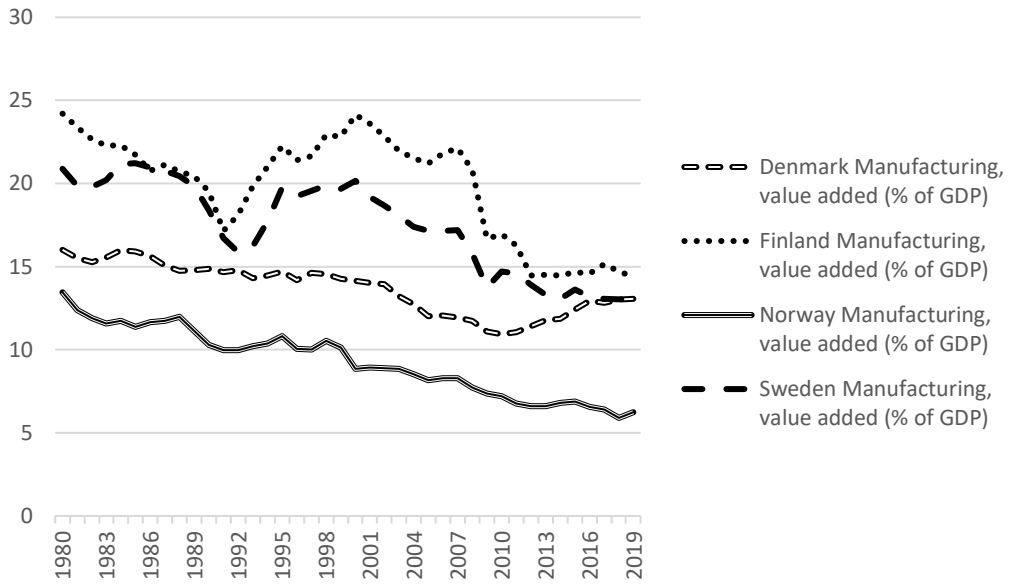

Figure 4. Value-added by manufacturing sector (% of GDP) (adapted from OECD website)

1.3 Research questions and aims

Since Nordic manufacturing firms' competitive environment has been fast changing due to shifting corporate policies, regulatory developments, and market dynamics, it is interesting to evaluate the trend and pattern of financial competitiveness over a period. In this regard, the current study applies entropy-based financial competitiveness evaluation index that measures firms' financial competitiveness, through four categories of indicators: profitability, solvency, sustainable development, and operational capacity.

The present research set out to explore the following research questions: first, whether stock market performance, financial risk, and corporate governance indicators affect the financial competitiveness of the Nordic manufacturing sector; second, whether stock market performance, financial risk, and corporate governance indicators affect each of the four components of financial competitiveness separately. Three additional research aims are intended to support the answers of the research questions: first, to form an understanding of the phenomena of financial competitiveness; second, to establish factors affecting financial competitiveness; third, to test and improve an existing model of evaluating financial competitiveness through entropy.

1.4 Research structure

The introduction introduces the reader to the topic of the research, provides an outlook on the statistics proving the significance of the topic. The “Literature review” highlights the in-depth literature review, which has helped to form various hypotheses. The “Research methodology” chapter addresses various aspects of the research design including data, variables, research methods, analysis model, and key variables. The “Research results” chapter reveals the analysis of the empirical findings and their interpretation. The “Discussion, limitations, and conclusion” chapter summarizes the empirical findings and discussed their relationship with the research questions. Furthermore, this chapter proposes the practical implications of the results, as well as stipulates the limitations and recommendations for future research.

2 Literature review

The following chapter presents a comprehensive summary of previous research on the subjects covered in the research. The objective of this literature review is to understand (1) the meaning of financial competitiveness, (2) indicators and models for calculating financial competitiveness, and (3) indicators of the phenomena which relate to financial competitiveness. In order to achieve these goals, the author selected the following literature for analysis (table 1). The presented concept matrix (Klopper, Lubbe, & Rugbeer 2007) provides an eagle's eye of the generated knowledge in the research process, and it will help the reader to navigate the study. The concept matrix comprises the literature related to competitiveness, financial performance, and corporate governance phenomena, and is organized as follows: (A) – the broad term of competitiveness; (B) – firm-level competitiveness; (C) – financial competitiveness; (D) - ratios and indicators for calculating financial competitiveness; (E) – corporate governance as an aspect of financial competitiveness; and (F) – financial risk as an aspect of financial competitiveness. The table includes an author, a year of publication and a title for easy reference to the reference list.

Articles	Concepts					
	A	B	C	D	E	F
Alben-Selcuk, E. 2016. Factors Affecting Firm Competitiveness: Evidence from An Emerging Market	x	x	x			
Altman, E. 1968. Financial Ratios, Discriminant Analysis and the Prediction of Corporate Bankruptcy				x		
Ambastatha, A., & Momaya, K. 2004. Competitiveness of Firms: Review of Theory, Frameworks and Models	x	x				
Barbuta-Misu, N. 2010. Assessing of the SME's Financial Competitiveness			x			
Beaver, W. H. 1966. Financial Ratios as Predictors of Failure				x		
Bredart, X. 2014. Financial Distress and Corporate Governance: The Impact of Board Configuration				x	x	
Buckley, P., Pass, L., & Prescott, K. 1988. Measures of international Competitiveness: A critical survey		x				
Cerrato, D., & Depperu, D. 2011. Unbundling the Construct of Firm-Level International Competitiveness	x	x	x			
Chikan, A. 2005. National and Firm Competitiveness: A General Research Model	x	x				
Claude B. E., Campbell R. H., & Tadas E. V. 2019. Political Risk, Economic Risk, and Financial Risk						x
Daily, C. M., & Dalton, D. R. 1994. Corporate Governance and the Bankrupt Firm: An Empirical Assessment				x	x	
D'Cruz, J., & Rugman, A. 1992. New Compacts for Canadian Competitiveness	x	x				
Dickson, D. P. 1992. Toward a General Theory of Competitive Rationality	x	x	x			

Feurer, R., & Chaharbaghi, K. 1994. Defining Competitiveness: A Holistic Approach	x	x	x			
Hult, T., Ketchen, D., Griffith, D., Chabowski, B., Hamman, M., Dykes, B., Pollitte, W., & Cavusgil, S. 2008. An Assessment of The Measurement of Performance in International Business Research			x			
Hundal S., Eskola A., & Lyulyu S. 2020. The Impact of Capital Structure on Firm Performance and Risk in Finland				x		x
Hundal, S. 2016. Busyness of Audit Committee Directors and Quality of Financial Information in India					x	
Hundal, S. 2017. Multiple directorships of corporate boards and firm performance in India					x	x
Jayachandran, S., & Varadarajan, R. 2006. Does Success Diminish Competitive Responsiveness? Reconciling Conflicting Perspectives	x					
Jensen, M. C., & Meckling, W. H. 1976. Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure					x	x
Lall, S. 2001. Competitiveness, Technology and Skills	x	x				
Latané, H. A., & Rendleman, R. J. Jr. 1976. Standard Deviations of Stock Price Ratios Implied in Option Prices						x
Liang, D., Lu, C.-C., Tsai, C.-F., & Shih G.-A. 2016. Financial ratios and corporate governance indicators in bankruptcy prediction: A comprehensive study				x		
Lin, F., Liang, D., & Chu, W.-S. 2010. The Role of Non-Financial Features Related to Corporate Governance In Business Crisis Prediction				x		
Martin, D. 1977. Early Warnings of Bank Failure: A Logit Regression Approach				x	x	
Mihaela, S. 2016. The Competition Between London Companies Regarding Their Financial Performance			x			

Mohammadi, P., Fathi, S., & Kazemi, A. 2019. Differentiation and Financial Performance: A Meta-Analysis					x
Murtha, T. P., & Lenway, S. A. 1994. Country Capabilities and The Strategic State: How National Political Institutions Affect Multinational Corporation's Strategies.	x	x			
Nafuna, E., Masaba, A. K., Tumwine, S., Watundu, S., Bonareri, T. C., & Nakola, N. 2019. Pricing Strategies and Financial Performance: The Mediating Effect of Competitive Advantage. Empirical Evidence from Uganda, a Study of Private Primary Schools	x	x	x	x	
Ohlson, J. 1980. Financial Ratios and the Probabilistic Prediction of Bankruptcy				x	
Pfeffer, J., & Salancik, G. 1978. *The External Control of Organizations: A Resource Dependence Perspective*					x
Pisano, G., & Teece, D. J. 2007. How to capture value from innovation: Shaping intellectual property and industry architecture		x			x
Porter, M. 1990. The Competitive Advantage of Nations	x	x			
Prahalad, C. K., & Hamel, G. 1990. The Core Competence of the Corporation					x
Rozsa, A., & Talas, D. 2015. Financial Competitiveness Analysis in the Hungarian Dairy Industry			x		
Saha, M., & Dutta, K. D. 2020. Nexus of Financial Inclusion, Competition, Concentration and Financial Stability: Cross-Country Empirical Evidence		x		x	
Schwab, K. 2019. The Global Competitiveness Report	x				
Solberg, E. 2014. How can the Nordic countries remain competitive?	x				
Teece, D. J. 2007. Explicating Dynamic Capabilities: The Nature and Microfoundations of (Sustainable) Enterprise Performance		x			x

Teece, D. J. 2011. *Human Capital, Capabilities and The Firm: Literati, Numerati, And Entrepreneurs in the 21st-Century Enterprise*		x		x
Teece, D. J. 2019. A Capability Theory of the Firm: An Economics and (Strategic) Management Perspective		x		x
Tomala, M. 2014. Economic Competitiveness of The Nordic Countries	x			
Wei, L., & Shao, L. 2013. Evaluation of The Financial Competitiveness of Chinese Listed Real Estate Companies Based on Entropy Method		x	x	x
Wu, J.-L. 2007. Do Corporate Governance Factors Matter for Financial Distress Prediction of Firms? Evidence from Taiwan				x

Table 1. Literature review concept matrix

2.1 The concept of competitiveness

The term "competitiveness" is common among academics and practitioners. However, due to the extensive use in describing various phenomena, there is no single definition of the term, and different academics define it differently. Since it is such a multidimensional concept, it takes various forms depending on the context and depth. As Feurer and Chahabarghi (1994) put it, "competitiveness is relative and not absolute." However, despite various opinions around the concept (and lack of agreement on the term's application), there is a consensus about three interrelated levels of competitiveness: country, industry, and firm. The idea of numerous academics in this field (D'Cruz, & Rugman 1992; Porter 1990) is that firm competitiveness is a foundation of any other level of competitiveness. For example, Porter (1990) points out that "firms, not individual nations, compete in international markets." It is noteworthy that the word "level" in this literature review does not specify importance. Instead, it underpins the author's observation about the main perspectives for measurement of competitiveness that the extant literature suggests. Following the above concepts, the present research has examined the competitiveness of firms.

The literature presents the term "firm competitiveness" in a multitude of forms. For example, Lall (2001) defines competitiveness as a firm's ability to do better than others in terms of profitability, sales, and market share. Chikan (2008) defines firm competitiveness as a firm's ability to

sustainably fulfill its double purpose: to meet customer needs at a profit. D'Cruz and Rugman (1992) define firm competitiveness as a firm's ability to sell better than competitors a product superior to those offered by competitors, considering its cost and non-cost aspects; thus, a firm's customers ultimately decide a firm's competitiveness. Likewise, Feurer and Chahabarghi (1994) define competitiveness as a conflicting balance of shareholder-customer values and financial strength; the latter determines the capacity to act and react within the competitive environment. The perspectives mentioned above offer a critical view of the phenomena. First, they give insight into how important a customer is in the formula of firm competitiveness as the primary decider of a firm's profitability from the demand side. Second, it provides perspective into the importance of financial strength for firm-level competitiveness. It defines maneuverability, arguably one of the most critical aspects of firm-level competitiveness in the global market's unpredictable environment.

Another concept that firm-level competitiveness also covers is collective learning, especially concerning an enterprise's coordination skills (Prahalad, & Hamel 1990). Collective learning affects the ability to capitalize on diverse production skills and integrate multiple streams of technologies (ibid.). Likewise, from the capability theory's point of view, a firm's competitiveness is defined by its ability to accumulate, maintain, and develop products (Teece 2019). Furthermore, the firm's market performance is also a crucial factor of its long-term competitive advantage; the firms that acquire and accumulate capabilities enjoy a sustainable competitive advantage (Teece 2007; Teece 2019). These perspectives underpin that the quality of leadership is one of the central drivers of firm-level competitiveness, which is practically one aspect of corporate governance. The quality of leadership can be viewed as a determinant of a firm's coordination skills, which defines its ability to accumulate capabilities, establishing its market performance.

From Buckley, Pass, and Prescott’s (1988) viewpoint, a firm's competitiveness is measured in three dimensions, also known as "three P's": performance - measures the outcomes of the firm-operations; potential – measures the inputs required to run the operations; and process – measures the managerial aspect of the operations in question. From the "three P's" perspective, a firm's competitiveness cannot be explained by a single measure since it is a complex and multi-layered phenomenon. For example, when statistical measures show that one firm has performed better than its competitors in the corresponding market and generated more competitive potential, it leaves room to explore the qualitative phenomenon associable with the management processes' success. This perspective also reveals that a firm's "potential" and "performance"

quantify, among other things, the same financial aspect - one is input, however, and another is output, respectively. Therefore, it logically follows that past and present performance indicators underline the competitive advantages that the firm possesses - but unless the qualitative aspect contributing to its success is studied and understood, the conclusions about the projection of its future success become questionable (Jayachandran, & Varadarajan 2006).

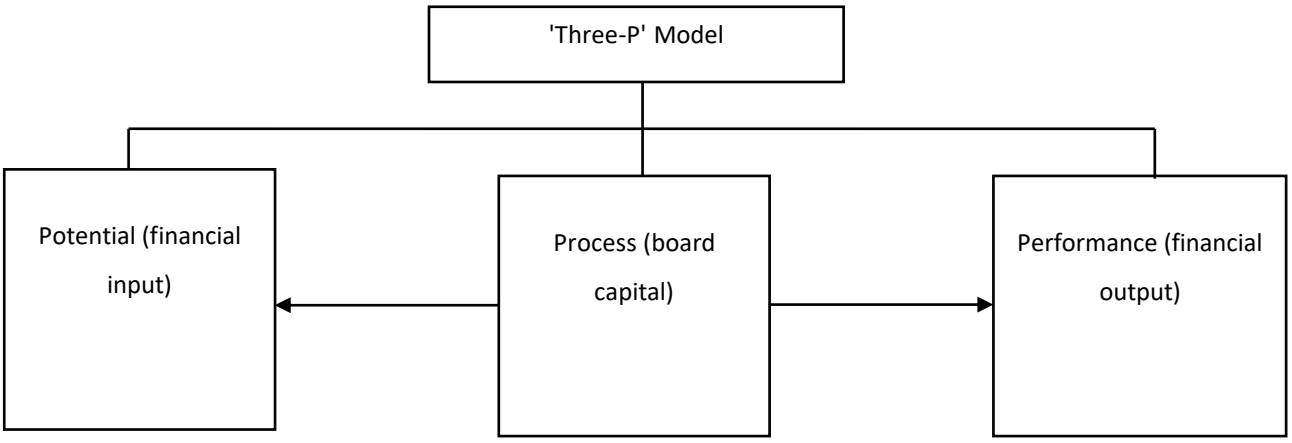

Figure 5. 'Three-P' model of Buckley and others (1988) (compiled by the author)

2.2 Determinants of financial competitiveness

The debate of financial performance being input and output of firm-level competitiveness generates compelling perspectives. The view of particular academics in the field is that financial performance is an outcome of competitiveness; for example, Cerrato and Depperu (2011) consider financial performance an outcome of competitiveness, or ex-post competitiveness. From this viewpoint, a line can be drawn with the idea of three P's: Cerrato and Depperu's financial performance is precisely the "performance" dimension, which measures the operation's outcomes. However, another side of the debate challenges that view. For example, Dickson's (1992) concept of organizational responsiveness states that competitive advantage depends on organizational responsiveness involving counteractions or adaptations to changes in the competitive environment. Furthermore, a company's organizational responsiveness is recognized by its financial strength, among other determinants (Feurer, & Chahabarghi 1994). In their regular operations or extraordinary circumstances, firms seek to employ financial strengths to implement strategic changes and improvements. From this perspective, the role of financial performance changes from "output" to "input." Again, a line can be drawn with the idea of three P's: this time, with the "potential" dimension, which measures the inputs required to run the operations. There are two additional aspects of financial performance acting as a contributor to the firm

competitiveness: first, the availability of short-term capital to finance the firm's liquidity and operational requirements; second, the availability of long-term capital to finance its strategic investments (ibid.). The contrary views emerging from the input/output debate about the view of financial performance indicators as a contributor/outcome of competitiveness do not necessarily create any ambiguity. Instead, they contribute to our understanding of the interplay between financial performance and competitiveness. This interplay can be explained by Figure 6 below.

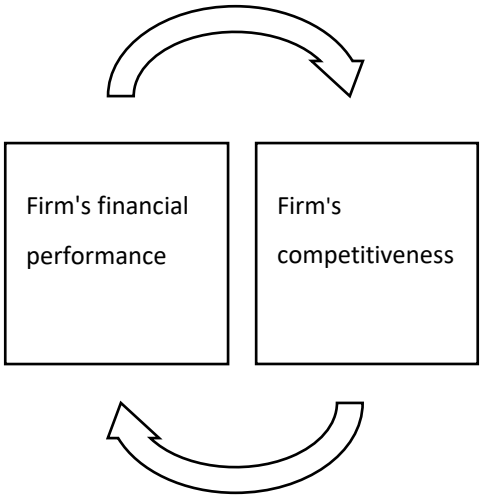

Figure 6. Interplay of financial performance and competitiveness (compiled by the author)

Researchers have studied the determinants of financial performance from many perspectives, for example, economics, strategic management, accounting, and finance (Alben-Selcuk 2016). Generally, the literature suggests that financial performance indicates how well a company generates revenues and manages its assets, liabilities, and stakeholders' financial interests. For a firm, the financial performance consolidates financial strategy, financial resources, financial capacity, financial performance, and financial innovation with its overall business objective (Kurt & Zehir 2016). The literature further suggests that a firm's financial performance can be explained significantly by its cost competitiveness (Nafuna, Masaba, Tumwine, Watundu, Bonareri, & Nakola 2019). That suggestion goes in line with the firm-level competitiveness definitions by Lall (2001), Chikan (2008), D'Cruz and Rugman (1992), as mentioned earlier. Furthermore, statistical literature has found a positive correlation between financial performance and cost competitiveness (Kurt, & Zehir 2016). According to Feurer and Chahabarghi (1994), cost competitiveness is one factor of firm-level competitiveness, a so-called shareholder-customer value; the two other factors are financial strength and human/technology potential. Furthermore, the balance between these factors defines a firm's competitiveness (ibid.); this balance is evident in the literature. Likewise,

Saha and Dutta (2020) emphasize the relevance of financial inclusion and financial stability to enhance firms' financial competitiveness.

Another fact of the matter is that financial competitiveness does not correlate only with financing. The literature further identifies several organizational characteristics such as managerial experience, board members' education, firm size, human resources, internal equity, firm age, and export and information channels (Tálas, & Rózsa 2015). Further literature appends operations, investing, and corporate governance characteristics (Hundal 2016; Hundal 2017). In particular, the role of a firm's board capital, including human capital (education, expertise, experience) and relational capital (a network of ties to other firms, external environment, and external contingencies), is highly relevant to enhance the knowledge and innovation horizon of firms (ibid.). There are several ways that a firm's board capital affects its financial competitiveness. According to the resource dependence theory, the higher quality board capital acts as a resource provider (Pfeffer, & Salancik 1978). Moreover, according to the agency theory, the higher quality board capital practically creates financial control, reward, and monitoring systems through its distinct functions: financial operating capacity, financial management capacity, and financial adaptability (Jensen & Meckling 1976).

The author's perspective on the literature suggests a connection between the concepts of board capital and dynamic capability, identified by the mentioned earlier resource dependence and firm's capability theories, respectively. For example, a firm builds up its dynamic capabilities to anticipate the ever-changing market conditions, resolve business-related obstacles, adopt new technologies, and apply them by realigning assets with activities (Pisano, & Teece, 2007; Teece, 2011). In this regard, the board capital's quality determines a firm's dynamic capabilities in the ever-changing market conditions. It logically follows then that strong dynamic capabilities promote the development of new products, processes, as well as improvements in organizational culture, accurate assessments of the changing business environment, and emerging opportunities.

Another idea that strongly relates to the concept of dynamic capabilities is the agency theory. It states that the pursuit of maximization of personal utility, or managerial short-termism approach, can provoke moral hazard, adverse selection, and information asymmetries (Jensen, & Meckling, 1976). From this perspective, the agency theory characteristics degenerate a firm's dynamic capabilities; with the managerial short-termism approach, a firm's management can no longer support its high performance according to the dynamic capabilities theory. Appropriate

managerial incentive systems and effective monitoring and control can reduce managerial short-termism approaches' effects to the minimum (ibid.). However, there are different opinions in the debate about the agency theory. For example, Mohammadi, Fathi, and Kazemi (2019) argue that not all the methods for reducing the short-termism approach's effect to the minimum are flawless. One illustration is that firms, which reward their managers based on periodic financial evaluations rather than evaluations of their longer-term strategic plans and initiatives, are less likely to support research and development (ibid.). On the other hand, Hundal, Eskola, and Lyulyu (2020) argue that managerial short-termism can discourage managers from supporting longer-term projects when their firms have higher than usual profits. This effect extends primarily to intangibles related to research and development due to the uncertainty of outcomes associated with such projects (ibid.). Furthermore, decreasing profits can incline a manager to increase expenditure on research and development projects. This increased expenditure might produce a positive signal to investors about growth-oriented commitments but be deceptive in reality and used as a ploy to preserve the managers in their firm (ibid.).

The phenomenon of a firm's financial risk exposure can further explain its financial competitiveness. Literature suggests a multitude of ways to measure a firm's financial risk exposure; the present study chooses a firm's daily stock price's standard deviation as the primary measure of financial risk exposure (Latané, & Rendleman 1976). The justification for using standard deviation comes from the concept of stock price movements (Claude, Campbell, & Tadas 2019); according to the concept, every stock price movement expresses a firm's future position in the financial markets. Therefore, the degree and extent of stock price movements of a firm show its financial risk exposure. The higher the degree of financial risk exposure of a firm, the higher its financial distress cost, which, if unaddressed, can cause a full-fledged bankruptcy (Wu 2007).

2.3 Indicators

The present study included financial performance indicators for determining the financial competitiveness of Nordic manufacturing firms. In this regard, the author aspires to defend the case for applying them. There are advantages of using financial performance indicators as financial competitiveness measures due to their wide acceptance as the key performance indicators (KPIs) and simplicity in their calculation and interpretations followed thereon (Altman 1968). Furthermore, there is a consensus in the extant literature that good competitiveness is indicated by strong financial performance since profitable opportunities result in higher production on the

supply side and higher sales on the demand side. However, despite its elegant simplicity, one financial performance indicator is not enough to determine the firm's financial competitiveness. Hult, Ketchen, Griffith, Chabowski, Hamman, Dykes, Pollitte, and Cavusgil (2008) assessed 96 articles that measured firms' financial performance and showed that one explanatory factor is not enough to explain a phenomenon. In this regard, the current research considers financial competitiveness as a multidimensional construct and includes indicators jointly in calculations. Furthermore, it is noteworthy that financial performance indicators alone do not hold much statistical significance – some statistical analysis must be applied to them, according to Altman (1968). He empirically proved that ratios take on a greater statistical significance than sequential ratio comparisons if analyzed in a multivariate framework (ibid.).

The author further argues that financial competitiveness studies are highly comparable to corporate bankruptcy prediction studies. They both study firm's financial performance and corporate governance; the firm's bankruptcy is the opposite of a firm's competitiveness, but the determinants of both are the same indicators. Therefore, the present study has interpreted some of the theoretical principles of a firm's bankruptcy. The main focus of the following paragraphs is to: (1) theoretically justify and improve the financial performance indicator system proposed by Wei and Shao (2013); (2) identify the determinants of financial competitiveness in the form of corporate governance; (3) identify any other relevant financial performance indicators and their relationships. Hence, the author discusses the findings from relevant studies below.

By combining financial and corporate governance indicators, Wu (2007) has evaluated existing models for predicting a firm's financial distress. The study based its financial ratios selection based on both Altman's (1968) and Ohlson's (1980) studies and put forward 16 financial ratios divided into five categories: liquidity, profitability, operation capability, financial structure, and cash flow. Furthermore, ten corporate governance indicators were chosen based on Martin's (1977) and Daily and Dalton's (1994) researches. The study concludes that from the financial performance side, quick ratio, return on equity, net profit margin, and account receivables turnover significantly impact the estimated probability of a financial crisis; the results also indicate that seven corporate governance variables, which are the percentage of shares held by institutional shareholders, the extent of concentration, cash flow rights, the ratio of cash flow to control rights, the ratio of board

seats held by outside directors and supervisors, management participation and stock pledge ratio, have a significant impact on the financial distress predictive probability (Wu 2007).

A similar study by Lin, Liang, and Chu (2010) has looked into the financial performance and corporate governance variables and machine learning technics of corporate governance bankruptcy prediction. The study has used the works of Altman (1968), Beaver (1966) and Ohlson (1980) to combine 23 financial performance indicators. The study has also used the findings of Bredart (2014) and Wu (2007) to combine 42 corporate governance indicators. The study has used an exhaustive search method to select the 4 most significant financial performance ratios out of 23 and 6 corporate governance variables out of 42. The study shows that financial ratios belonging to solvency and turnover categories and corporate governance variables belonging to board structure and ownership structure underscore bankruptcy prediction with a greater degree of accuracy than others.

In a different research, Liang, Lu, Tsai, and Shih (2016) attempted to improve the bankruptcy prediction models using machine learning based on Taiwanese manufacturing firms' financial data. Basing their propositions on Altman's (1968) and Beaver's (1966) works, among else, the authors combined 95 financial ratios in 7 categories: solvency, capital structure, growth, profitability, turnover, cash flow, and others. Furthermore, their study identified 42 corporate governance indicators. The results of the study showed that among financial performance indicators, profitability and solvency categories were the most effective in predicting bankruptcy. Furthermore, the critical part of the study's discussion is that a combination of both financial and non-financial indicators creates the most accurate models. Another interesting observation of the study is that corporate governance indicators and other non-financial indicators are used much more often in the studies of the emerging markets than that of the developed markets like the US; this is due to the high investor protection in the developed markets, where the corporate structure is considered exogenous.

Borrowing the idea of entropy from information theory, Wei and Shao (2013) created a model that evaluates the financial Competitiveness of Chinese-listed real estate companies. This model's inputs contain 17 fundamental financial performance indicators, covering profitability, solvency, sustainable development, and operational capacity. The output is an index system, a scoreboard in its essence, with companies scoring 0 to 1. The model defines the dispersion among indicators and defines each indicator's statistical weight relative to each other. In the current study, the entropy

technique has been applied to measure the Nordic manufacturing sector setting's financial competitiveness.

2.4 Hypotheses

The study examines the following hypotheses:

H_1: Firm-level corporate governance indicators affect the financial competitiveness score.

H_{1a}: Firm-level corporate governance indicators affect the profitability capability component of the competitiveness score.

H_{1b}: Firm-level corporate governance indicators affect the solvency component of the competitiveness score.

H_{1c}: Firm-level corporate governance indicators affect the capacity for sustainable development component of the competitiveness score.

H_{1d}: Firm-level corporate governance indicators affect the operation capacity component of the competitiveness score.

H_2: Firm-level stock market performance indicators affect the financial competitiveness score.

H_{2a}: Firm-level stock market performance indicators affect the profitability capability component of the competitiveness score.

H_{2b}: Firm-level stock market performance indicators affect the solvency component of the competitiveness score.

H_{2c}: Firm-level stock market performance indicators affect the capacity for sustainable development component of the competitiveness score.

H_{2d}: Firm-level stock market performance indicators affect the operation capacity component of the competitiveness score.

H_3: Firm-level financial risk exposure affects the financial competitiveness score.

H_{3a}: Firm-level financial risk exposure affects the profitability capability component of the competitiveness score.

H_{3b}: Firm-level financial risk exposure affects the solvency component of the competitiveness score.

H_{3c}: Firm-level financial risk exposure affects the capacity for sustainable development component of the competitiveness score.

H_{3d}: Firm-level financial risk exposure affects the operation capacity component of the competitiveness score.

3 Research methodology

The research methodology directs the study effort; it creates a process; it reveals the philosophy behind the research and methods used for data collection and data analysis. This chapter describes the research methodology, on which all the research methods were chosen and discloses the whole process of data collection and analysis. Additionally, it considers ethical issues concerning the quality of data in the research.

3.1 Research design

A research design is a philosophy underpinning all the methods used to conduct research (Adams, Khan, Raeside, & White 2007). It has a double purpose: first, it helps meet the objectives and answer questions of the research, second, it generates knowledge for further research (ibid.). Furthermore, methodology creates clarity in solving the research problem systematically (Kothari 2004). In principle, research design considers the logic behind the research itself and guides methods and techniques. Therefore, a clear and concise research design is essential in adopting a critical and analytical view of the research process's data (ibid.). In this regard, a research needs to determine its approach and philosophy.

The central intention of the present research is to establish factors affecting financial competitiveness. Therefore, the author chooses a quantitative approach to accurately measure large amounts of data (Robson, & McCartan 2016). Furthermore, the author chooses positivism philosophy, as it is traditionally linked with the quantitative approach (ibid.). Positivism helps create generalizations based on quantitative data, similar to those produced by natural scientists; those generalizations contribute more toward a practical side of the results (Saunders 2009). This

philosophy allows the present study to observe the objective facts and analyze the hypotheses based on those observations (Robson, & McCartan 2016). In line with the aspiration for generalizations, the author chooses a deductive approach as a satellite to the positivism philosophy; this approach allows the author to measure the facts quantitatively and apply the deduction to test the hypotheses (Saunders 2009). Lastly, since the present research bases itself on six years of panel data, the author considered it a longitudinal study, to which the mono-method was applied because all the data is numerical (ibid.).

3.2 Entropy method

After a careful review of the relevant literature, the present study attempts to improve the Wei and Shao's (2013) model and method for determining financial competitiveness. First, the present research suggests discarding the "cost-profit rate" indicator to evade the duplication of indicators, resulting in deterioration of results, since the similar indicator "operating profit" is already present in the original calculation. The reason for keeping the latter is its widespread use and concrete formula across the extant literature. Second, the original method includes indicators specific for real estate firms due to their operation characteristics, e.g., illiquid assets. For example, a real estate firm might use "hedging and proliferating rate" to calculate its defense against risk through futures contracts; since this firm is dealing with a lesser liquid asset, it might want to hedge itself against the volatility of the real estate market. This hedging measure might not apply to such an extent to a manufacturing company, since its assets are more liquid than that of a real estate firm. In this regard, the present study proposes to replace "hedging and proliferating rate" with "intangible assets growth rate". Moreover, the literature suggests that a firm's commitment to growing intangible assets is an excellent indicator of its sustainable growth rate (Hundal et al. 2020). Intangible assets are a firm's intellectual property - patents, copyrights, goodwill, trademarks, franchises; their growth rate indicates an increase in intellectual capital and commitment to continuous research and development. To the same extent of adding generalizability, the present research has suggested discarding the capital intensity indicator since it does not represent all industries. Table 2 presents the final set of variables used in the entropy method applied in the current research.

Category	Indicator
Profitability capability	Operating profit ratio
	Return on assets
	Return on invested capital
Solvency	Debt coverage ratio
	Current ratio
	Operating cash flow to operating profit ratio
	Debt asset ratio
Capacity for sustainable development	Sustainable growth rate
	Intangible assets growth rate
	Total assets annual growth rate
	Revenue annual growth rate
	Net profit annual growth rate
Operation capacity	Receivables turnover ratio
	Inventory turnover
	Total assets turnover

Table 2. Financial competitiveness score categories of variables and variables

The last point applies to the formula of entropy, more specifically to the distribution of probabilities. The formula proposed by Wei and Shao is as follows,

$$H_j = -\int_0^1 \varphi_j(x) \ln \varphi_j(x) dx$$

Where $\varphi_j(x)$ is the Cumulative Distribution Function, which is a monotonically increasing function, which brings a continuous data set. The author suggests using Sturges' rule (Sturges

1926) to determine the optimal finite number of intervals instead of Kernel Density Estimation. In this case, there are as many probabilities, as there are intervals, which brings a discrete set of data, which calls for summation in the entropy formula,

$$H_j = -\sum_{i=1}^{n} p_i \ln(p_i)$$

The usage of Sturges' rule results in a discrete data set, which follows the original formula of Shannon (1948) more closely.

3.3 The principle of entropy and financial competitiveness score calculation

Rudolf Clausius introduced the concept of entropy in 1850. He linked it with the process of energy loss in the combustion reactions due to friction or dissipation; the more entropy is generated, the less energy is left over to do useful work. The process describes the second law of thermodynamics – to put it simply, the entropy, or disorder, is always increasing in a closed system. Almost a hundred years later, the concept of entropy found use in information theory, describing an analogous loss of data in the process of information transmission. Shannon (1948) proposed the concept in 1948; it measures information through uncertainty, or level of "surprise," as it is often interpreted. Shannon proved that the entropy H is of the form,

$$H = -\sum_{i=1}^{n} p_i \log p_i$$

Where $\{p_1, p_2, ..., p_n\}$ are the probabilities of a set of events. In information theory, entropy is a measure of uncertainty, or in other words, entropy quantifies the informativeness of a random variable. The lower the probability of a random variable, the greater amount of information it carries, the lower its entropy is; and vice versa, the higher the probability of a random variable, the lower the amount of information it carries, the greater its entropy is.

The extant statistical literature regarding the entropy method suggests that entropy offers a conceptually simple, practical, and unifying view of predictive statistics (Esteban, & Morales 1995; Akaike 1982). However, Akaike (1982) argues that any model is only a formulation of our past experience; from this perspective, only a new experience can support a useful model's creation.

Following the ideas as mentioned above, the present study aimed to improve the existing model of evaluating financial competitiveness, as well as to apply an existing model of evaluating corporate governance and market performance health – thus creating a hybrid, where one model explains another, as shown further in the methodology chapter.

In this model, entropy is used to determine the dispersion of an indicator. The logic behind it is as follows: the greater the entropy, the greater the dispersion of indicators, which in turn means the greater weight of indicators. The basic principle of entropy directs through four steps of evaluating financial competitiveness:

3.3.1 Normalization of indicators

The selected indicators are in different measurement units; using them "as is" would lead to inconsistency. To this extent, every indicator must be adjusted relative to each other or normalized. The Min-Max Feature Scaling was used to bring all values into the range [0, 1]. For the positive indicators, meaning the higher the value, the better, the normalized data S_{ij} of indicator *j* of a firm *i* is calculated as,

$$S_{ij} = \frac{r_{ij} - \min\limits_{1 \le k \le m} r_{ik}}{\max\limits_{1 \le k \le m} r_{ik} - \min\limits_{1 \le k \le m} r_{ik}}$$

where r_{ij} is the *j*th original indicator of the *i*th company, *m* is the number of indicators, and *n* is the number of companies. For the negative indicator, meaning the smaller the value, the better, the normalized data S_{ij} is computed as,

$$S_{ij} = \frac{\max\limits_{1 \le k \le m} r_{ik} - r_{ij}}{\max\limits_{1 \le k \le m} r_{ik} - \min\limits_{1 \le k \le m} r_{ik}}$$

3.3.2 Distribution of probabilities and calculation of entropy

Let R_j be a set of data of indicator *j* for all companies; then, the distribution of indicator *j* is estimated first by applying Sturges' rule to R_j and then by calculating the probability for each interval. Let *n* be the number of intervals, then the formula of entropy *H* for the indicator *j* is as follows,

$$H_j = -\sum_{i=1}^{n} p_i \ln(p_i)$$

Where p_i is the probability in the ith interval.

3.3.3 Calculation of weight

For determining the importance of each indicator, the discrete weight function is used. The weight w for indicator j, is given by

$$w_j = \frac{H_j}{\sum_{k=1}^{m} H_k}$$

where H_j is the entropy of indicator j, and m is the number of indicators.

3.3.4 Calculation of financial Competitiveness

The consolidated score assesses financial competitiveness. The consolidated score F_i for a company i is the function of its non-dimensionalized indicators S_{ij}, and weighted by w_j,

$$F_i = \sum_{j=1}^{m} w_j S_{ij}$$

3.4 Data collection

The sample selection was performed taking into account the availability of data and relevant literature. In the current study, a sample of 96 manufacturing publicly listed firms has been selected to test the hypotheses. Twenty-eight firms have been chosen from Finland and Sweden each, whereas twenty-three and seventeen firms represent Denmark and Norway, respectively. The unbalanced pooled data covers a period of six years (2013 to 2018). The final sample is 513 firm-years, and the country-wise classification is 149 firm-years (Finland), 152 firm-years (Sweden), 122 firm-years (Denmark) and 90 firm-years (Norway). The stock market data have been obtained from four stock exchanges – Nasdaq Stockholm, Oslo Stock Exchange, Nasdaq Copenhagen, and Nasdaq OMX Helsinki – based in Sweden, Norway, Denmark, and Finland respectively. The data related to the accounting and corporate governance variables have been extracted from the annual reports (especially financial statements and corporate governance reports) of the sample firms. The source of the stock market performance data is S&P Global Market Intelligence.

3.5 Indicators

Table 3 features the description of variables representing multiple phenomena. These phenomena describe financial competitiveness, corporate governance, or board of directors' characteristics, stock market performance, and risk exposure in the current study. Furthermore, firm size was taken as a control variable, calculated as natural logarithm of total assets of a firm.

Variables	Label	Definition/Formula
Phenomenon 1: Financial competitiveness score (dependent variable)		
Operating profit ratio	Y1	operating profit or loss / total revenue
Return on Assets	Y2	net profit / total assets
Return on invested capital	Y3	(net income - dividend) / (debt + equity)
Debt coverage ratio	Y4	(earnings before interest, tax, depreciation, and amortization) / (interest plus principal)
Current ratio	Y5	current assets / current liabilities
Operating cash flow to operating profit ratio	Y6	operating cash flow / net income
Debt asset ratio	Y7	(current liabilities + non-current liabilities) / total assets
Sustainable growth rate	Y8	return on equity * (1 − dividend payout ratio)
Intangible assets growth rate	Y9	((intangible assets year 2 - intangible assets year 1) / intangible assets year 1) * 100
Total assets annual growth rate	Y10	((total assets year 2 - total assets year 1) / total assets year 1) * 100
Revenue annual growth rate	Y11	((total revenue year 2 - total revenue year 1) / total revenue year 1) * 100

Net profit annual growth rate	Y12	((net income year 2 - net income year 1) / net income year 1) * 100
Receivables turnover ratio	Y13	revenue / net receivables
Inventory turnover	Y14	total revenue / ((inventory at the beginning of the period + inventory at the end) / 2)
Total assets turnover	Y15	total revenue / ((total assets year 1 + total assets year 2) / 2)
Phenomenon 2: Corporate governance (independent variable)		
Board size	CG1	Number of directors on the board of directors. Natural logarithm values have been used in the regression analysis.
Board education	CG2	Level of education of directors on a firm board of directors on a scale 0-4 in a year: no education (0), up-to high school (1), bachelor level (2), master level (3), doctorate (4). Natural logarithm values have been used in the regression analysis.
Board experience	CG3	Number of years of experience of executive directors on a firm board of directors in a year. Natural logarithm values have been used in the regression analysis.
Board discipline	CG4	The median ratio of board of directors' meetings attendance to total meetings held in a year.
Director share ownership	CG5	The ratio of share owned by directors (outside and executive) to the total share outstanding.
CEO share ownership	CG6	The ratio of share owned by CEO to the total share outstanding.
Performance-based pay of CEO	CG7	The ratio of the performance-based pay to the total pay of the CEO of the firm in a year.
Phenomenon 3: Stock market performance (independent variable)		

Annualized stock market return	M1	Realized firm-level daily stock return annualized.
CAPM	M2	The Capital Asset Pricing Model (CAPM) determines the minimum return on equity that must be generated given the market risk.
Jensen's alpha	M3	Jensen's alpha is a risk-adjusted performance measure that represents the average return, above or below that predicted by the capital asset pricing model (CAPM), given the portfolio's or investment's beta and the stock annual return.
Annualized stock market return (risk adjusted)	M4	Realized firm-level daily stock return annualized divided by total risk (systematic and unsystematic).
Phenomenon 4: Risk (independent variable)		
Systematic risk	R1	R1 represents the portion of total risk exposure of a firm arising due to the market risk and is measured as the product of β and annualized standard deviation of the corresponding index return.
Unsystematic risk	R2	R2 represents the portion of total risk exposure of a firm arising due to the firm-specific factors. It is a residual risk derived after subtracting R1 from R3.
Total risk	R3	R3 represents the total risk (volatility) that the stock market performance of firms is exposed to. It is measured by deriving the annualized standard deviation of daily stock return of firms.
Control variable		
Firm size	S	Firm size is measured by total assets on balance sheet. Natural logarithm values have been used in the regression analysis.

Table 3. Description of variables

3.6 Principal component analysis and derived factors

The current study uses several econometric techniques to analyze the financial competitiveness score, including ordinary least squares multivariate linear regression (OLS MLR) and principal

component analysis (PCA). In a typical OLS MLR model, the explanatory variables are represented by the X-matrix with the order M × N, whereas the explained variable is represented by a single vector, Y, an M × 1 vector, so that the model can be written as Y = Xb. The solution vector "b" is ascertained by solving $b = (X'X)^{-1}X'Y$, that is by multiplying the inverse of the product of the explanatory variable and its transpose with the product of transpose of the explanatory variable and explained variable. The variance of the estimated solution is given by $V(b) = (X'X)^{-1}S^2_E$, that is, the variance of the solution E vector "b" is obtained by multiplying the inverse of the product of the explanatory variable and its transpose with the variance of standard error (Jolliffe 1987). It follows that the columns of the X matrix are uncorrelated. However, in reality, the columns of X-matrix are often correlated, and it is not even a problem as long as the coefficients of correlation are moderate and not significant.

The current study has taken multiple indicators of the various phenomena to make an in-depth analysis. However, the mutual association between the explanatory variables presents a possibility of multicollinearity, which can jeopardize the variables' reliability.

In Table 2, the categories comprise multiple variables, which can be correlated with one another. For example, sustainable growth rate, intangible assets growth rate, total assets annual growth rate, revenue annual growth rate, and net profit annual growth rate are likely to be correlated. In a situation where there is a *high* likelihood of a *high* correlation between variables falling under the same category, not only some explanatories become redundant, but the high correlation between them can lead to multicollinearity problems in the multivariate linear regression (MLR) analysis, which can adversely affect the reliability of empirical findings (Cadima, & Jolliffe 1995).

To avoid such a situation in the empirical analysis, the principal component analysis (PCA) technique has been applied to analyze the data in the current study (ibid.). The PCA, which essentially is a dimension reduction technique, filters-out lesser important variables so that relatively important variables, known as principal components or factors, stay in the analysis and provide unbiased and reliable results. Thus, principal component analysis applied in the current study as follows:

$$Y_{it} = a_{it} + \sum_{k=1}^{p} \beta_k Z_{it} + \beta_s S_{it} + \varepsilon_{it}$$

Where Y_{it} is a variable of a firm *i* in the period *t*, a_{it} is an intercept term, Z_{it} corresponds to the principal component representing *i*th firm in *t*th period, S_{it} represents the firm size, and ε_{it} is the error term. And the MLR model applied in the current study as follows:

$$Y_{it} = a_{it} + \sum_{k=1}^{p} \beta_k CG_{it} + \sum_{k=1}^{q} \beta_k M_{it} + \sum_{k=1}^{r} \beta_k R_{it} + \beta_s S_{it} + \varepsilon_{it}$$

Where Y_{it} is a variable of a firm *i* in the period *t*, a_{it} is an intercept term, CG_{it} corresponds to the corporate variables representing *i*th firm in *t*th period, M_{it} corresponds to the stock market performance variables representing *i*th firm in *t*th period, and R_{it} corresponds to the financial risk variables representing *i*th firm in *t*th period, S_{it} represents the firm size, and ε_{it} is the error term. The principal components, or factors, derived from the MLR model are then analyzed using OLS MLR, where the solution vector b can be obtained by solving the following equation:

$$b = (Z'Z)^{-1}Z'Y$$

The tables 4 and 5 present the results of PCA method analysis decomposing the phenomenon of financial competitiveness as dependent variable and the phenomena of corporate governance, stock market performance, and financial risk as independent variables, respectively. The results of these analyses are used in the PCA method MLR analysis.

Variables	
Profitability factor (E1)	Operating profit ratio
	Debt coverage ratio
Solvency factor (E2)	Operating cash flow to operating profit ratio
	Sustainable growth rate
Capacity for sustainable development factor (E3)	Total assets annual growth rate
	Intangible assets growth rate
Operation capacity factor (E4)	Current ratio
	Dept/assets ratio
	Total assets turnover
	Inventory turnover

Table 4. Principal components derived from dependent variables representing categories of indicators

Variables	
Corporate governance factor (Z_1)	Board size
	Board education
Stock market performance factor (Z_2)	Jensen's alpha
	Annualized stock market return
Financial risk factor (Z_3)	Unsystematic risk
	Total risk

Table 5. Principal components derived from independent variables representing categories of indicators

4 Research results

The following chapter provides and interprets the empirical findings. The chapter contains threes sections. The first section presents the results of descriptive statistics and provides a general overview of the variables. The second chapter presents relationships between variables through the correlation analysis. The third section presents the results of two analyses: the OLS MLR PCA (PCA method applied to the ordinary least squares multivariate linear regression) analysis with dependent variables decomposed and OLS MLR PCA analysis with both dependent and independent variables decomposed.

4.1 Descriptive statistics

Descriptive statistics are given in Table 6. The mean board-level independence is 54.3%, whereas the highest and the lowest independence are 64.3% and 32%, respectively. Similarly, the median performance-based pay of the CEO of the sample firms is 61.6%, whereas the highest level is 89%. The mean values of education and experience of independent directors have been more than those of their executive director colleagues. As measured by the median ratio of the board of directors' meetings attended to total meetings held in a year, the discipline level is well over 90%. The highest share ownership of directors is 47.2%, whereas the mean value is 3.8%. In the stock market performance phenomena, annualized stock market return (M1), CAPM (M2), Jensen's Alpha (M3), and risk-adjusted annualized stock market return (M4) show a mean of 0.88, 0.13, and 0.75 and 0.85, respectively. Furthermore, the mean systematic risk exposure is over two times greater than the mean unsystematic risk faced by the sample firms. Conclusively, the mean financial competitiveness score calculated based on the entropy method (E) is 0.46, whereas the lowest and highest are 0.25 and 0.67, respectively.

Descriptive statistics

	Range	Minimum	Maximum	Mean	Std. Deviation	Variance
Y1	15.84	-14.71	1.13	-0.03	0.75	0.58
Y2	8.32	-4.93	3.39	0.02	0.24	0.06
Y3	3.37	-1.66	1.71	0.05	0.15	0.02
Y4	18.92	-7.82	11.10	2.30	1.66	2.77
Y5	20.81	0.19	21.00	2.10	1.71	2.94
Y6	398.66	-45.33	353.33	2.33	15.99	255.73
Y7	8.34	0.04	8.38	0.54	0.30	0.1
Y8	67.71	-63.00	4.71	-0.06	2.06	4.26
Y9	1238.33	-194.83	1043.50	44014	38.42	1476.41
Y10	31594.99	-0.99	31594	0.12	0.49	0.24
Y11	16.18	-0.99	15.19	0.14	0.83	0.7
Y12	491.27	-211.75	279.52	0.05	13.81	190.71
Y13	7238.77	0.56	7239.33	25.69	296.97	88193.08
Y14	359.95	0.01	359.96	11.56	25.22	636.26
Y15	41699	0.00	41699	1.08	0.46	0.22
CG1	13	3	16	7.56	2.02	4.11
CG2	88	7	95	19.72	8.04	64.79
CG3	112	1	113	38.81	21.86	478.2
CG4	0.77	0.23	1	0.96	0.08	0.007

CG5	0.66	0	0.66	0.09	0.15	0.02
CG6	0.29	0	0.29	0.01	0.04	0.002
CG7	0.75	0	0.75	0.20	0.12	0.01
M1	161.66	-0.81	160.85	0.88	9.46	89.51
M2	0.46	0.02	0.48	0.13	0.08	0.001
M3	161.2	-0.83	160.37	0.75	0.11	0.01
M4	161.71	-0.87	160.84	0.85	17046	89.52
R1	0.50	-0.03	0.47	0.12	0.07	0.005
R2	41640	0.05	43831	0.25	0.14	0.02
E	0.42	0.25	0.67	0.46	0.07	0.006
S	9.66	16.71	26.37	22.26	1.99	3.97

CG1 - board size, CG2 - board education, CG3 - board experience, CG4 - board discipline, CG5 - director share ownership, CG6 - CEO share ownership, CG7 - performance pay of CEO, M1 – annualized stock return, M2 - CAPM determined return on equity, M3 – Jensen's Alpha, M4 - annualized stock return divided by total risk, R1 - systematic risk, R2 - unsystematic risk, E - competitiveness score calculated based on entropy method. Total number of observations = 513.

Table 6. Descriptive statistics of the variables

4.2 Correlation analysis

Table 7 and 8 shows two panels, (A) and (B), displaying the pairwise correlation of coefficients of various explanatory variables. In the current research, the variables that have been subject to the analysis belong to four fundamental phenomena: financial competitiveness score as the dependent variable; corporate governance, stock market performance, and risk as independent variables. Table (A) shows a significant correlation between the variables representing the phenomena of corporate governance and phenomena of stock market, risk, and financial competitiveness score. For example, the board experience variable (CG3) has a significant correlation with annualized stock return (M1), unsystematic risk (R2), and financial competitiveness score (E). Similarly, table (B) shows a significant correlation between the

phenomena of the stock market performance and financial competitiveness score. For example, Jensen's Alpha (M3) significantly correlates with the financial competitiveness score (E). Furthermore, systematic risk (R1) and unsystematic risk (R2) negatively correlate with the financial competitiveness score (E), with systematic risk correlating more significantly.

In Tables 7 and 8 (Panel A and B, respectively), it can be observed that there is a high correlation between the variables representing the phenomenon of corporate governance. For example, panel A shows that board size (GC1), board education (GC2), and board experience (CG3) are highly correlated. Similarly, in panel B, a high correlation between variables underpinning the risk phenomena has been observed. For example, the annualized stock return (M1) and Jensen's Alpha (M3) are significantly correlated. Due to the high correlation between the variables within the various phenomena, it was considered to apply the PCA to filter-out lesser important variables and obtain critical factors, which have been used as explanatory variables in the OLS MLR analysis.

Correlations A

	CG1	CG2	CG3	CG4	CG5	CG6	CG7
CG1	1	.527***	.310***	.019	-.282***	-.251***	-.007
CG2	.527***	1	.112	.023	-.232***	-.114*	-.116*
CG3	.310***	.112*	1	.018	.215***	.105*	-.025
CG4	.019	.023	.018	1	-.073	-.079	-.053
CG5	-.282***	-.232***	.215***	-.073	1	.255***	0.018
CG6	-.251***	-.114*	.105*	-.079	.255***	1	-.135*
CG7	-.007	-.116*	-.025	-.053	.018	-.135*	1
M1	.422***	.203***	.129**	.113*	.292***	.124**	.244***
M2	-.059	-.036	-.091	.336***	-.014	.006	.107
M3	.139**	.028	.078	-.003	-.082	-.003	-.033
M4	-.06	-.037	-.092	-.336***	-.013	.006	.108
R1	.359***	.183***	.124**	.101	-.274***	-.121**	.216***
R2	-.291***	-.257***	-.164***	-.183***	.177***	.194***	-.154**
E	.212***	-.052	.206***	.003	.028	-076	.092*
S	.373***	.343***	.102*	.045	-.223***	-.106*	-.025

Significant at *** p < 0.01, ** p < 0.05, and * p < 0.10. CG1 - board size, CG2 - board education, CG3 - board experience, CG4 - board discipline, CG5 - director share ownership, CG6 - CEO share ownership, CG7 - performance pay of CEO, M1 – annualized stock return, M2 -CAPM determined return on equity, M3 – Jensen's Alpha, M4 - annualized stock return divided by total risk, R1 - systematic risk, R2 - unsystematic risk, E - competitiveness score calculated based on entropy method. Total number of observations = 513.

Table 7. Pairwise correlation of the variables (table A)

Correlations B

	M1	M2	M3	M4	R1	R2	E	S
CG1	.422***	-.059	.139**	-0.06	.359***	-.291***	.212***	0,373***
CG2	.203***	-.036	0.028	-0.037	.183***	-.257***	-0.052	0,343***
CG3	.129**	-.091	0.078	-0.092	.124**	-.164***	.206***	0,102*
CG4	.113*	.336***	-0.003	.336***	0.101	-.183***	0.003	0,045
CG5	.292***	-.014	-0.082	-0.013	-.274***	.177***	0.028	-.223***
CG6	.124**	.006	-0.003	0.006	-.121**	.194***	0.076*	-.106*
CG7	.244***	.107	-0.033	0.108*	.216***	-.154**	0.092*	-.025
M1	1	-.003	.138**	-0.004	.851***	-.245***	.140**	-.060
M2	-.003	1	0.002	.036***	.054	.413***	0.103	-.066
M3	.138**	.002	1	-0.009	0.086	-0.109*	.164***	-.035
M4	-.004	.036***	-0.009	1	0.053	.414***	0.105*	-.106*
R1	.851***	.054	0.086	0.053	1	-.202***	-.205***	.207***
R2	-.245***	.413***	-0.109*	.414***	-.202***	1	-0.013*	-.213***
E	.140**	.103	.164***	0.105*	-.205***	-0.013*	1	-.098*
S	-.059	-.066	-.035	-.106*	.207***	-.213***	-.098*	1

Significant at *** p < 0.01, ** p < 0.05, and * p < 0.10. CG1 - board size, CG2 - board education, CG3 - board experience, CG4 - board discipline, CG5 - director share ownership, CG6 - CEO share ownership, CG7 - performance pay of CEO, M1 – annualized stock return, M2 - CAPM determined return on equity, M3 – Jensen's Alpha, M4 - annualized stock return divided by total risk, R1 - systematic risk, R2 - unsystematic risk, E - competitiveness score calculated based on entropy method. Total number of observations = 513.

Table 8. Pairwise correlation of the variables (table B)

4.3 Regression analysis

Table 9 presents the OLS MLR PCA (PCA method applied to the ordinary least squares multivariate linear regression) analysis with principal components derived from dependent variables representing categories of financial competitiveness indicators (E to E4). Following is the description of the significant coefficients retrieved from the analysis. The table shows that full financial competitiveness (E) is positively affected by the board of directors' experience (CG3), annualized stock return (M1), and Jensen's Alpha (M3). Full financial competitiveness is negatively affected by the CAPM determined return on equity (M2), systematic (R1), and unsystematic risk (R2). The first component of financial competitiveness, profitability (E1), is positively affected by board education (CG2), performance pay of CEO (CG7), and annualized stock return (M1). Furthermore, the profitability component (E1) is negatively affected by CAPM determined return on equity (M2), risk-adjusted annualized stock return (M4), and systematic (R1), unsystematic (R2), and total (R3) risk. The second component of financial competitiveness, solvency (E2), is positively affected by board size (CG1), board education (CG2), board discipline (CG4). The data showed that solvency (E2) is negatively affected by the board's experience (CG3), CAPM determined return (M2), both systematic (R1) and unsystematic risk (R2), as well as total risk (R3). Surprisingly, firm size (S) also negatively affects solvency (E2) in the data. The third component of financial competitiveness, capacity for sustainable development (E3), is positively affected by the board education (CG2), performance pay of CEO (CG7), annualized stock return (M1), and Jensen's Alpha (M3). Moreover, capacity for sustainable development (E3) is negatively affected by CAPM determined return on equity (M2) and unsystematic risk (R2). The last component of financial competitiveness, operation capacity (E4), is positively affected by the board size (CG1), board education (CG2), board experience (CG3), board discipline (CG4), performance pay of CEO (CG7), annualized stock return (M1), and Jensen's Alpha (M3). In contrast, operation capacity (E4) is negatively affected by systematic (R1), unsystematic (R2), and total (R3) risk. The observations are further discussed in the next section of the research.

Financial competitiveness score (Predicted Variable) – Coefficients					
	Full financial competitiveness (E)	Profitability (E1)	Solvency (E2)	Capacity for sustainable development (E3)	Operation capacity (E4)
Intercept	.768	.073	.149	-.095	.316
CG1	.046 (.570)	.017 (.201)	.152* (1.973)	.060 (.910)	.006* (1.677)
CG2	.028 (.387)	.006** (2.119)	.068* (1.909)	.109* (1.695)	.064* (1.918)
CG3	.031*** (3.780)	.050 (.815)	-.133* (-1.831)	.033 (.505)	.013*** (3.965)
CG4	.055 (.665)	-.011 (-.177)	.015* (1.600)	.053 (.655)	.145* (1.849)
CG5	.026 (.377)	.009 (.142)	.103 (1.387)	-.056 (-.864)	.012 (.174)
CG6	.019 (.264)	-.054 (-.905)	.072 (.970)	-.021 (-.323)	-.055 (-.835)
CG7	.092 (1.353)	.029*** (3.955)	.068 (.931)	.050** (2.258)	.028* (1.637)
M1	.252*** (3.322)	.076* (1.674)	-.084 (-1.152)	.132** (2.039)	.283*** (4.319)

M2	-.237***	-.066***	-.066***	-.219***	-.043
	(-5.258)	(-6.871)	(-2.724)	(-7.472)	(-.691)
M3	.002***	.076	-.052	.001**	.001***
	(3.712)	(1.074)	(-.702)	(2.039)	(4.326)
M4	.098	-.601***	-.040	-.091	-.130
	(.619)	(-5.878)	(-.314)	(-1.229)	(-1.142)
R1	-.043*	-.092***	-.094***	-.057	-.052*
	(-1.619)	(-6.110)	(-2.624)	(-.879)	(-1.785)
R2	-.181***	-.064***	-.038*	-.131*	-.243*
	(-4.638)	(-5.878)	(-1.614)	(-1.757)	(-1.972)
R3	-.091	-.010***	-.005**	-.073	-.009***
	(-.823)	(-6.291)	(-1.986)	(-1.089)	(-4.836)
S	.007**	.133*	-.162**	.097*	-.007***
	(2.223)	(1.930)	(-1.973)	(1.504)	(-5.877)
Durbin-Watson	1.839	1.850	1.891	1.888	2.127
Psuedo-R^2	.268	.240	.196	.283	.229
F-statistic	12.568	22.288	6.132	22.826	21.112

Significant at *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$. CG1 – natural logarithm of board size, CG2 – natural logarithm of board education, CG3 – natural logarithm of board experience, CG4 – board discipline, CG5 – director share ownership, CG6 – CEO share ownership, CG7 – performance pay of CEO, M1 – annualized stock return, M2 – CAPM determined return on equity, M3 – Jensen's Alpha, M4 – annualized stock return divided by total risk, R1 – systematic risk, R2 – unsystematic risk, R3 – total risk, S – firm size measured by total assets. E, E1, E2, E3 and E4 – financial competitiveness score calculated based on entropy method for full financial competitiveness, profitability competitiveness, solvency competitiveness, capacity for sustainable development competitiveness and operation capacity competitiveness, respectively. Total number of observations = 513.

Table 9. Effects of variables representing corporate governance, market performance, risk, and size on financial competitiveness components

The table 10 presents the OLS MLR PCA analysis with principal components derived from independent variables on the vertical axis (Z_1 to Z_3) and principal components derived from dependent variables on the horizontal axis (E to E4). Following is the description of the significant coefficients retrieved from the analysis. First, the corporate governance component (Z_1) has a notable positive effect on profitability (E1), solvency (E2), and capacity for sustainable development (E3) components of financial competitiveness and overall financial competitiveness (E). Second, the stock market performance component (Z_2) positively affects all financial competitiveness components (E1, E2, E3, E4) and overall financial competitiveness (E). Third, the financial risk component (Z_3) has a significant adverse effect on the capacity for sustainable development (E3) and operation capacity (E4) components of financial competitiveness, and overall financial competitiveness (E). In contrast, the financial risk component (Z_3) has a positive effect on profitability. A possible explanation for the above-mentioned contrasting observation might be an inverse relationship, where firms' higher profitability results in higher investor's interest, resulting in increased financial market speculation, leading to increased volatility, betas, and therefore risk. The observations are further discussed in the next section of the research.

Financial Competitiveness score (Predicted Variable) – Coefficients					
	Full financial competitiveness (E)	Profitability (E1)	Solvency (E2)	Capacity for sustainable development (E3)	Operation capacity (E4)
Intercept	.524	.068	.165	.084	.312
Z_1	.137**	.084***	.052*	.108*	.024
	(2.317)	(3.432)	(2.127)	(1.648)	(1.618)
Z_2	.001**	.124*	.047*	0.001*	.001***
	(2.432)	(1.672)	(1.696)	(1.834)	(4.948)
Z_3	-.018*	.007***	-.007*	-.002	-.016***
	(-1.880)	(3.069)	(-1.631)	(1.255)	(-4.470)
S	.001	0.002**	-0.010	.005*	-.007***
	(.195)	(2.266)	(-1.111)	(1.892)	(-4.956)
Durbin-Watson	1.889	1.897	1.835	1.862	2.089
Psuedo-R^2	.233	.169	.224	.185	.293
F-statistic	12.695	6.323	11.107	8.115	14.071

Significant at *** $p < 0.01$, ** $p < 0.05$, and * $p < 0.10$. Z_1 – corporate governance factor, Z_2 – stock market performance factor, Z_3 – financial risk factor, S – firm size measured by natural logarithm of market capitalization. E, E1, E2, E3 and E4 – financial competitiveness score calculated based on entropy method for full competitiveness, profitability competitiveness, solvency competitiveness, capacity for sustainable development competitiveness and operation capacity competitiveness, respectively. Total number of observations = 513

Table 10. Effect of components (Z_1 to Z_3) and size on financial competitiveness components (E to E4)

5 Discussion, limitations, and conclusion

This chapter of the research aims to summarize and clarify the research results to answer the research questions and test hypotheses. Furthermore, the chapter explains the limitations of the present research and provides recommendations and suggestions for further research. Lastly, the chapter discusses the practical implications in the conclusion section, where the research is drawn to an end.

5.1 Discussion

The current research has two central questions: first, whether financial market performance, financial risk, and corporate governance affect financial competitiveness; second, whether financial market performance, financial risk, and corporate governance affect each of the four components of financial competitiveness separately. The current study applies two OLS MLR PCA analyses to answer these questions. In the first OLS MLR analysis, independent variables from various phenomena are regressed without any prior statistical analysis. The second OLS MLR analysis uses the PCA method to decompose the independent variables into three components representing relevant phenomena. The reasoning for using the PCA method is that the correlation analysis shows a significant association between specific indicators from the related phenomena. The PCA method eliminates less relevant variables and instead extracts key components, which are used in the OLS MLR analysis as independent variables. While the OLS MLR PCA analysis with dependent variables decomposed provides insight, the OLS MLR PCA analysis results address the hypotheses and resolve the current study's central questions.

The following paragraph discusses the findings (table 9) of the OLS MLR PCA analysis with dependent variables decomposed. First, a possible explanation of CAPM (M2) and risk-adjusted stock annual return (M4) negatively affecting specific financial competitiveness components is that they inherently contain some risk measure. For example, from the formula, a stock's CAPM determined return is significantly influenced by its beta, which is a risk measure. Moreover, the risk-adjusted stock annual return is calculated based on total risk. A possible suggestion for further research might be to include both of these measures into the risk phenomenon alongside systematic, unsystematic, and total risk. Second, an additional fact that indicators from the risk phenomenon (R1 to R3) also negatively affect financial competitiveness leads to the conclusion that risk-based indicators have a negative impact on financial competitiveness score. Third and

last, a possible reason for the negative effect of firm size (S) on solvency (E3) might be the nature of higher-asset manufacturing firms' operation, which requires larger initial investments causing higher debt, causing reduced equity. The next section addresses the hypotheses and the current study's central questions with the help of findings (table 10) of the OLS MLR PCA analysis.

H_1: Firm-level corporate governance indicators affect the financial competitiveness score.

> *H_{1a}: Firm-level corporate governance indicators affect the profitability capability component of the competitiveness score.*
>
> *H_{1b}: Firm-level corporate governance indicators affect the solvency component of the competitiveness score.*
>
> *H_{1c}: Firm-level corporate governance indicators affect the capacity for sustainable development component of the competitiveness score.*
>
> *H_{1d}: Firm-level corporate governance indicators affect the operation capacity component of the competitiveness score.*

The first group of hypotheses, related to corporate governance as a proxy of financial competitiveness, is supported by the findings of OLS MLR PCA analysis. The data suggests that corporate governance indicators, specifically board size and board education, positively affect the financial competitiveness score (H_1). Moreover, corporate governance indicators affect most significantly profitability (H_{1a}), solvency (H_{1b}) and capacity for sustainable development (H_{1c}). In contrast, operation capacity (H_{1d}) is not affected in a significant manner. The reason behind these relationships might be that by having a multitude of diverse opinions expressed during board meetings due to a higher number of directors and higher level of academic education among directors, a firm can choose to try both less traditional ways of operating and the best prospects to do so.

H_2: Firm-level stock market performance indicators affect the financial competitiveness score.

> *H_{2a}: Firm-level stock market performance indicators affect the profitability capability component of the competitiveness score.*
>
> *H_{2b}: Firm-level stock market performance indicators affect the solvency component of the competitiveness score.*

H_{2c}: Firm-level stock market performance indicators affect the capacity for sustainable development component of the competitiveness score.

H_{2d}: Firm-level stock market performance indicators affect the operation capacity component of the competitiveness score.

The second group of hypotheses also holds up to the findings of OLS MLR PCA analysis. The analysis shows that the stock market performance, specifically Jensen's Alpha and annualized stock return, positively and significantly affect all four components (H_{2a}, H_{2b}, H_{2c}, H_{2d}) of the financial competitiveness score, as well as the overall financial competitiveness score (H_2). The possible explanation might be that financial performance, to some degree, acts as an input into financial competitiveness and determines the financial strength, which in turn defines the ability to act and react within the changing market conditions, which conclusively decides the firm's ability to do better than others in terms of sales, profitability and market share.

H_3: Firm-level financial risk exposure affects the financial competitiveness score.

H_{3a}: Firm-level financial risk exposure affects the profitability capability component of the competitiveness score.

H_{3b}: Firm-level financial risk exposure affects the solvency component of the competitiveness score.

H_{3c}: Firm-level financial risk exposure affects the capacity for sustainable development component of the competitiveness score.

H_{3d}: Firm-level financial risk exposure affects the operation capacity component of the competitiveness score.

The last group of hypotheses are further reinforced by the findings of the OLS MLR PCA analysis. In contrast to previous phenomena, financial risk phenomenon, especially unsystematic risk and total risk variables, has a negative effect on financial competitiveness score (H_3). The analysis showed that solvency (H_{3b}) and operation capacity(H_{3d}) are affected negatively by financial risk. However, financial risk positively affects profitability capability (H_{3a}). A possible explanation for the above-mentioned contrasting observation might be an inverse relationship, where firms' higher profitability results in higher investor's interest, resulting in increased financial market speculation,

leading to increased volatility, betas, and therefore risk. With capacity for sustainable development (H_{3c}) the relationship is too insignificant to make a confident conclusion about the data.

5.2 Limitations and recommendations for further research

This section discusses the limitations of the current study and provides recommendations for further research. The first limitation of the current research is the data sample. The data sample applied in this study is only 513 firm-years, with the country-wise classification of 149 firm-years from Finland, 152 firm-years from Sweden, 122 firm-years from Denmark, and 90 firm-years from Norway. As mentioned above, the data sample cannot provide a full and detailed picture of the markets of these countries; more data is needed for a more significant statistical result. In this regard, it would be interesting to (1) extend the firm-years by extending the observation period, (2) observe the overall change of financial competitiveness of Nordic manufacturing firms and the dependence of financial competitiveness on phenomena used in this study over a longer time frame. Furthermore, other economic sectors might be considered for a more comprehensive view of the overall markets.

Additionally, the sample data covers four out of five countries of the Nordic region, which extends the usability of the data to Iceland. However, the sample data's main limitation is that the Nordic manufacturing sector is considered a single homogenous unit of analysis, which omits any cross-country differences.

The second limitation of the current research is the number of firms observed, which is 96. It is recommended to expand this number, whether further research will be applied to a more extensive period or not. The first reason is that there are more public listed manufacturing firms in the Nordic region; the second reason is that increasing the number of firms observed will increase the statistical significance of analysis' results.

The third limitation of the current research rises from the reversed association theory (Dunn, & Kirsner 1988), which decomposes the relationship between independent processes and their underlying effects. In other words, it studies the reversed relationship between dependent and independent variables. As mentioned above, the current research's findings section features one suspected reversed relationship between profitability and risk phenomena. This problem could be avoided in future research by choosing another set of variables and improving its quality.

The last limitation of the current research extends from the substantial theoretical lack of accumulated knowledge about financial competitiveness. This research urgently demands that the utmost importance of the practical definition of financial competitiveness must be recognized.

5.3 Conclusion

The topic of competitiveness is not new but is still relevant and widely discussed among practitioners and academics. The current research analyses competitiveness from the financial performance point of view. It makes a novel proposition that a firm's competitiveness does not explicitly determine a firm's financial competitiveness – it is instead a two-way street, where one feeds off another.

Furthermore, the current research provides a practical and unifying method for determining firms' financial competitiveness in the Nordic manufacturing sector. It is based on the entropy method and uses 15 variables from 4 related phenomena. The current study applies 15 additional variables from 4 distinct phenomena to analyze this method, bringing a total of indicators to 30. The total number of firm-year observations is 513, with 96 firms from the Nordic manufacturing sector examined. The analysis shows that financial competitiveness is positively affected by corporate governance and stock market performance phenomena. The risk exposure phenomenon harms financial competitiveness; however, it positively affects the profitability component of financial competitiveness.

The major contribution of the current study is developing a theoretical framework for determining the firm's financial competitiveness and developing a theoretical framework for determining an orderly and sequential pattern of mutual causalities. Furthermore, it is the first study of its kind in the Nordic setting.

The development of the entropy method, as well as any other statistical method, begins from the in-depth study of one real phenomenon. It shows us that the emphasis must be placed on the search for critical and practical problems – to stimulate the development of new interesting and useful models and the overall progress. The last sentence forms the conclusion of the current research.

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Appendices

Appendix 1. Distribution of financial competitiveness index (math is beautiful)