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The Financial Performance of Cluster Firms in Germany

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Abstract

This thesis uses statistical analysis to determine whether spatial agglomeration externalities manifest in the enhanced financial performance of cluster firms in Germany. Cluster theory remains a continuously debated phenomenon due to a wide range of cluster definitions, ambiguous empirical research and the involvement of multiple research streams, for example, economics, spatial sciences and sociology. Nevertheless, the common denominator in cluster theory is the increased innovative performance of cluster firms due to positive externalities compared to non-cluster firms. Hence, the financial performance of cluster firms should be enhanced because of their exposure to positive externalities. This thesis is based on the foundations of Marshall-Arrow-Romer’s theories on intra-industry externalities and Porter’s theories on the competitive advantage of firms. Following the theory outline, a novel approach for empirical research within cluster theory is developed. Empirical data of over 25.000 German companies across 110 industries has been gathered. A developed Python algorithm identified clusters within each firm’s 5km, 15km and 25km radii. Following the cluster identification, Kruskal-Wallis variance analyses were conducted for each industry. The conducted empirical research does not find a significant difference in financial performance between cluster and non-cluster firms. What becomes apparent is that the focus on solely spatial agglomeration of same industry firms does not lead to enhanced financial performance. Hence, positive agglomeration externalities are triggered by additional factors besides spatial agglomeration. The objective to provide an empirical analysis of the financial performance of German cluster firms in comparison to their non-cluster peers has been met by this work. However, further research needs to be conducted to determine which additional factors provide positive spatial agglomeration externalities leading to increased innovative output and, thus, enhanced financial performance.

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List of Abbreviations

ANOVA	Analysis of Variance
EBITDA	Earnings before Interest, Depreciation and Amortisation
EEG	Evolutionary Economic Geography
GEM	Groundings, Enterprises and Markets
KPI	Key Performance Indicator
LLS	Local Labour Systems
MAR	Marshall – Arrow – Romer
RIC	Reuters Instrument Code
ROA	Return on Assets
ROCE	Return on Capital Employed
ROE	Return on Equity
ROI	Return on Investment
R&D	Research and Development
SME	Small and Medium Enterprises
VBA	Virtual Basic for Applications

1 Clusters – a legitimate innovation system?

Over the past decades, clusters and their impact on innovative activities have emerged as a popular research topic within economics. One of the main reasons is the transition towards a "knowledge-based economy", meaning that a firm's competitiveness strongly depends on its capability to apply existing and new knowledge to its products and processes.[1] Innovating firms tend to achieve higher profit margins.[2] Additionally, the significantly increased globalisation has led to a highly competitive environment for firms, enhancing the need for continuous innovations to generate sustainable financial streams.[3] Without innovation, firms will not survive the dynamic market environment nowadays.[4]

Today's dynamic competitive environment requires firms to adapt company strategies to foster product and process innovations and thus ensure their long-term survival. This behaviour is recommended in modern economic growth theories.[5]

Due to the dynamic competitive environment, two major consequences have developed. First, firms have distinct and unique but limited resources and capabilities.[6] Thus, companies try to efficiently apply their resources and capabilities to obtain a competitive advantage.[7] Hence, firms become increasingly specialised and adopt niche strategies.[8] Consequently, an increased number of network relations across the value chain and strategic alliances or in other words, "alliance capitalism", has been established in this modern economic system.[9]

Second and more important, the significant economic change required the scientific community to rethink the understanding of innovation. Innovation is no longer acknowledged as a straightforward linear process. Innovation results from a series of interactions between (a) capabilities and stimuli created within firms and industries and (b) macroeconomic causes external to the individual industry, for example, the development of

[1] See Dess et al. (2000), p.18-19; MacKinnon et al. (2011), p.246
[2] See Geroski et al. (1993), p.208
[3] See Roelandt (1999), p.9-10; Botazzi et al. (2008), p.711; Bigliardi (2013), p.245
[4] See Hult et al. (2004), p.429
[5] See for example Aghion et al. (1997); Porter (1998b), p.13; Freeman et al. (2000)
[6] See Curado et al. (2018), p.2
[7] See Barney et al. (2001), p.625-626
[8] See Roelandt (1999), p.11
[9] See Dunning (2014), p.14-16

new scientific methods across different sectors.[10] Hence, innovation is a dynamic and complex process involving multiple actors and institutions. Their continuous interactions shape the dynamic of the innovation process; thus, actors and institutions play a significant role in innovation.

Table 1: Triggers of innovative activities

Internal	**External**
Capabilities	State of Science
Stimuli generated within each firm	Supply of technical capabilities (engineers)
Stimuli generated within industries	Conditions controlling geographical mobility
	Market conditions (demand growth, interfirm competition)
	Financial facilities (criteria for allocation of funds)
	Macroeconomic trends (prices of inputs and outputs)
	Public policies (tax codes, patent laws)

Source: Based on Dosi (1988), p.1121

Due to this systemic character, the approach of innovation systems and their linkages became increasingly relevant for researchers, firms and policy makers.[11] Innovation systems are all analysed on the systemic level. However, they differ significantly in the objective and level of analysis (supranational, regional, sectoral or technological systems).[12]

One subcategory of innovation systems is the cluster approach. Cluster theory is based upon agglomeration economies and was popularised by Michael Porter and his famous book "The competitive advantage of nations" in 1990. A cluster can be described as a geographically bound production network of strongly interdependent firms linked to each other along the value chain.[13]

[10] See Dosi (1988), p.1121
[11] See Roelandt (1999), p.9
[12] See Roelandt (1999), p.11
[13] See Roelandt (1999), p.9

Research on clusters has revealed a positive theoretical impact on cluster firms' innovation rate mainly because of externalities such as elusive knowledge spillovers.[14] Externalities are defined as additional effects from conducting one activity to another without being directly represented in market values.[15] This elusive, diffuse and tacit knowledge provides the foundation for innovative activity. Interaction and exchange of such knowledge are bound on spatial proximity.[16] Additionally, productivity and resilience are positively associated with cluster membership.[17]

Today’s intense global competitive environment forces corporations to maintain a steady focus on innovation given the positive correlation between a firm’s profitability and its innovation output.[18] Therefore, a firm’s long-term survival depends upon its capability to innovate and enhance its financial business performance. Thus, the impact of positive cluster externalities on innovation and business performance should be assessed using a practical dataset to validate the theoretical concepts. This research aims to provide deeper insights into the firm-level effects, particularly the financial performance of geographically co-located firms. The geographic research scope is limited to Germany.

At first, the term cluster will be defined, and its multifaceted interpretations will be discussed. Following, the theory of agglomeration economies will be presented. Additionally, due to its importance, knowledge spillover will be explained in-depth. After that, the diamond model by Michael Porter and its implications on clusters will be displayed. A short summary of the cluster approach and its theoretical implications on innovation and firm performance will be given. The current status of empirical research on clusters and firm performance will provide a final overview of the current state of the cluster literature.

Subsequently, the need for an alternative analytical approach and its methodology will be explained. Afterwards, the results of the analysis will be displayed and discussed. Finally, a conclusion and future outlook for further research will be given.

[14] See Breschi et al. (2001), p.975; Beaudry et al. (2009), p.320
[15] See Beaudry et al. (2009), p.320
[16] See Bathelt et al. (2004), p.32
[17] See Baptista et al. (1998), p.526
[18] See Geroski et al (1993), p.208; Bottazzi et al. (2008), p.712

2 The cluster term and its multifaceted interpretations

The term *cluster* refers to accumulation, bundle, concentration or grouping.[19] Scientists from different disciplines use the term cluster to describe specific phenomena within their respective fields.[20] Due to the mixture of different scientific perspectives, the previously listed related terms are often used interchangeably with clusters.

For the purpose of this work, the term cluster will be used in the context of spatial economic activity. Despite various economists' attempts to define, structure and classify the term cluster, the scientific community lacks a joint understanding due to the term's universality.[21] Rosenfeld even states, "There are as many definitions as there are types of organisations using the term."[22]

The following table provides an overview of the various cluster definitions and perspectives.

Table 2: Multifaceted cluster definitions[23]

Reference	Citation
Swann et al. (1996), p.1139	"Clusters are here defined as groups of firms within one industry based in one geographical area."
Rosenfeld (1997), p.4	"A cluster is very simply used to represent concentrations of firms that are able to produce synergy because of their geographic proximity and interdependence, even though their scale of employment may not be pronounced or prominent."
Baptista et al. (1998), p.525	"A geographical cluster is defined here as a strong collection of related companies located in a small geographical area, sometimes centred on a strong part of a country's science base."

[19] See Pieper (2013), p.42
[20] See Zürker (2007), p.21
[21] See Malmberg et al. (1996), p.86; See Newlands (2003), p.526
[22] Rosenfeld (1997), p.8
[23] Own summary of academic definitions of regional clusters

Feser (1998), p.10	"Economic clusters are not just related and supporting industries and institutions, but rather related and supporting institutions that are more. competitive by virtue of their relationships."
Porter (2000), p.15	"Clusters are geographic concentrations of interconnected companies, specialised suppliers, service providers, firms in related industries, associated institutions in a particular field that compete but also cooperate."
Van den Berg et al. (2001), p.187	"The popular term cluster is most closely related to this local or regional dimension of the network. Most definitions share the notion of clusters as localised networks of specialised organisations, whose production processes are closely linked through the exchange of goods, services and/or knowledge."
Steinle et al. (2002), p.850	"Clusters are localised sectoral agglomerations of symbiotic organisations that can achieve superior business performance because of their club-like interactions."
Beaudry et al. (2003), p.326	"We take a rather pragmatic approach and define a geographical cluster as a strong collection of related companies located in a relatively small geographical area."
Bathelt (2005), p.205	"The term cluster is used to refer to a localised industry configuration, such as a local or regional concentration of industrial firms, and their support infrastructure which are closely interrelated through traded and untraded interdependencies."

Considering the outlined definitions above, it is noticeable that scholars consider clusters as local networks. Some scholars take one step further and argue that cluster theory can be considered a sub-research stream of ecosystem theory because clusters are value-creating systems with a geographic dimension.[24]

These multifaceted definitions are considered problematic as heterogenous definitions lead to inconsistency in research meaning that findings and methodologies are not easily comparable due to the underlying inconsistent core definitions. Hence, data interpretation

[24] See Schiele et al. (2008), p.29; Schiele et al. (2014), p.108

lack comparability. Another problem occurs in the effective communication of research results. If the understanding of a spatial cluster is homogenous, communication between researchers, policymakers and practitioners will be more precise and less prone to misinterpretations. Hence, a uniform understanding and definition of the term spatial cluster is essential for a consistent research field that provides robust results and transfers into sound practical decision-making by policy makers and practitioners.

Nevertheless, the majority of economic definitions describe the activities of different actors within rather undefined spatial proximity.[25] It is important to acknowledge that the idea and observation of firms clustering in close proximity to one another are not new to the scientific world. Despite Porter being considered the godfather of the cluster theory, the British economist Marshall observed local agglomerations of firms first and described them as industrial districts.[26] Hence Marshall's work must be acknowledged as the cornerstone of agglomeration theory which translated later into cluster theory.[27] Due to the relevance for the understanding and development of cluster theory, Marshall's theories will be discussed in greater detail in the following chapter 3. It is important to acknowledge, that the term cluster does not occur within the agglomeration literature stream. Hence, the following chapter refers to "spatial agglomerations" which transfer into the term cluster by Michael Porter and his work.

[25] See Pieper (2013), p.16
[26] See Marshall (2014)
[27] See Newlands (2003), p.522

3 Unravelling agglomeration economies: Exploring external factors and their impact on firm performance and spatial economic development

The concept of agglomeration economies describes the spatial development of economic activity over time.[28] The central underlying assumption is the existence and formation of externalities due to the spatial co-location of firms and institutions.[29] Precisely, this means that firms that are located next to other firms gain benefits such as knowledge spillovers due to the pure spatial proximity to each other.[30]

Natural resources like coal or even natural infrastructure like rivers and their importance for transportation leads to the spatial agglomeration of firms.[31] Hence, the agglomeration of firms can occur as the outcome of static natural tendencies which minimise transportation and transaction costs.[32] However, it is also argued that the agglomeration of firms can serve as a dynamic growth determinant due to localisation and urbanisation advantages.[33] These agglomeration economies have been thoroughly discussed and have remained an important analytical element of the industry and firm location for over a century within academic literature. Additionally, agglomeration economies provide insights into the structure of city-size distributions, urban systems and regional development policies.[34]

Because of the wide-ranging nature of the term agglomeration economies and its long history within the academic literature, the concept of agglomeration economies has been exposed to new introductions of definitions and classifications which have at least partially challenged the existing definitions and classifications. Consequently, the concept of agglomeration economies has been assigned various meanings and thus reflects different concepts with different foci.[35]

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[28] See Frenken et al. (2005), p.8
[29] See Melo (2009), p.332; Wixe (2015), p.2054
[30] See Frenken et al. (2005), p.9; Melo (2009), p.332
[31] See Lerch (2009), p.13
[32] See Caragliu et al. (2016), p.91
[33] See Caragliu et al. (2016), p.92
[34] See Parr (2002b), p.151-152; Mukkala (2004), p.2420
[35] See Parr (2002b), p.151-152

However, Frenken et al. provide a broad definition that comprises the majority of definitions and classifications associated with agglomeration economies throughout academic literature.

"Agglomeration economies concern external economies from which a firm can benefit by being located at the same place as one or more other firms."[36]

The large body of literature follows this focus on external agglomeration economies. However, Parr argues that agglomeration economies should be viewed two-fold. First, the intra-firm economies and second, the inter-firm economies. Both types of economies need to be analysed along the scale, scope and complexity dimensions.[37]

Taking the firm's perspective, the internal economies of scale could, for example, refer to the spatial consolidation of production facilities. However, it is important to acknowledge that economies of scale do not necessarily require the spatial element. The element of geographic proximity is crucial to consider these types of scale economies as overarching agglomeration economies.[38]

Considering the dimension of scope, such economies occur from shared inputs, joint utilisation of a manufacturing facility or other input factors that, after the acquisition, can be deployed freely to multiple production processes.[39] Parr refers to the diversification of production to two or more similar products that share the same production facility, adding geographic proximity.[40]

Lastly, academic literature describes economies of complexity, referring to the division of production processes into technological stages. Economies of complexity deal with the vertical integration of inputs into multiple production processes or stages, while economies of scope only refer to lateral integration meaning multiple final products.[41] Considering the

[36] Frenken et al. (2005), p.9
[37] See Parr (2002b), p.153
[38] See Harrison (2007), p.110; Parr (2002b), p.153
[39] See Willig (1979), p.346; Parr (2002a), p.718
[40] See Parr (2002b), p.155
[41] See Teece (1980), p.224; Parr (2002b), p.156

addition of the element of geographic proximity, economies of complexity as agglomeration economies may be generated by the efficient flow of production components between production stages.[42]

As described above, agglomeration economies can occur within a firm. Thereby, intra-firm economies do not necessarily require the element of spatial proximity. Furthermore, this research is concerned with the external agglomeration economies of firms. Hence the intra-firm economies will be neglected in the further context of this research, and the previous explanations just provide basic holistic knowledge.

The core benefit of agglomeration theory is the existence of positive spatial externalities in the form of knowledge spillovers. Consequently, an overview on knowledge spillovers will be given to precede a comprehensive exploration of agglomeration and cluster theory.

3.1 Knowledge Spillover – the path to innovation?

In academic literature, knowledge spillovers have been defined as ‘working on similar things and hence benefitting much from each other’s research’.[43] Referring to the innovation process, a foundational knowledge stock of a firm’s market, including customers and competitors, is a prerequisite for any innovative activities. Furthermore, accessing and applying newly generated knowledge is at the heart of the innovation process and ensures the firm's long-term survival in the nowadays dynamic business environment.[44] However, firms require an absorptive capacity to acknowledge new important knowledge and then leverage it to maximise its value.[45] Hence, economic growth and prosperity depend upon human capital accumulation and its application in goods and services.[46]

[42] See Parr (2002b), p.156
[43] See Griliches (1992), p. 36-37
[44] See Cohen et al. (1990), p.128-129; Audretsch et al. (1996), p.630; Karlsson et al. (2001), p.105 in Fischer et al. (2001)
[45] See Cohen et al. (1990), p.128
[46] See Teece (1981), p.8, Lucas (1993), p.270

In general, firms usually cannot fully protect and utilise their produced knowledge and the underutilised knowledge spills over to other firms.[47] Underutilised in this context refers to knowledge generated within one firm but not (fully) applied in the firm's technology. Additionally, patenting technologies require the publication of the specific knowledge applied within the technology, which in turn does not fully provide protection from alteration.[48] Thus, the knowledge generator unintentionally increases other organisations' knowledge stock and innovative capacity.[49] Hence, a firm's capability to absorb and efficiently exploit knowledge spillovers impacts its respective innovative activity.

These knowledge spillovers or localised learning[50] is the core concept within the agglomeration economics theory. Because of the unanimous acknowledgement of the existence of knowledge spillover, scholars controversially discuss whether knowledge spillovers are geographically bounded or not.[51] Nevertheless, it is widely acknowledged and observed that innovative activity tends to cluster within some industries.[52] Hence, some form of endogeny exists that fosters geographical agglomeration of economic activity.[53]

Karlsson et al. emphasise the different concepts of knowledge and information. Thus, before digging into the theoretical concept of knowledge spillover, a common understanding of the terminology knowledge and a distinction between knowledge and information needs to be made.[54]

Information can be described as data that can easily be codified and stored. One important characteristic of information is the potential subdivision into smaller pieces. Hence, information can be accessed and transferred without restrictions. In contrast, knowledge is intrinsically indivisible and cannot easily be codified.[55] In this context, academics usually

[47] See Romer (1986), p.1003
[48] See Karlsson et al. (2001), p.105 in Fischer et al. (2001)
[49] See Karlsson et al. (2001), p.105-106 in Fischer et al. (2001); Beaudry et al. (2009), p.320
[50] See Malmberg et al. (2006), p.2
[51] See Karlsson et al. (2001), p.102 in Fischer et al. (2001)
[52] See Jaffe et al. (1993), p.579
[53] See Audretsch et al. (1996), p.634
[54] See Karlsson et al. (2001), p.103 in Fischer et al. (2001)
[55] See Kobayashi et al. (1993), p.221

use the term tacit or elusive knowledge, which refers to human expertise and human skills both embodied in technical problem-solving.[56] It is important to acknowledge that the application of knowledge to problem-solving capabilities provides the value of knowledge, not solely the possession of information. Hall emphasises that humans are "the subjects – not the objects of their own experience."[57] It is important that firms understand the complexity of information and knowledge and enhance the firm's absorptive capacity by establishing structures that allow for the recognition, transformation and distribution of knowledge.[58]

In the endogenous growth literature stream, knowledge is considered as the very narrow concept of a generated research & development (R&D) or a learning-by-doing output. Contrary, within economic geography, academics apply a much broader concept of knowledge with the inclusion of organisational and market knowledge, which is in line with Marshall's (1890) initial conceptualisation.[59]

A distinction between different types of knowledge can be made, namely (a) scientific knowledge, (b) engineering or technical knowledge and (c) entrepreneurial knowledge. Scientific knowledge is considered foundational knowledge, whereas engineering knowledge is the application and embeddedness of scientific knowledge in newly developed goods and services. It is important to acknowledge that technical knowledge can only be codified to a certain extent, for example, blueprints. However, the technological knowledge behind the blueprint and its transfer requires the exchange of skilled labour.[60]

Lastly, entrepreneurial knowledge concerns business-relevant information about consumers, markets and business models. A learning-by-doing approach often creates this type of knowledge. Due to the nature of entrepreneurial knowledge being a distinctive competitive

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[56] See Polanyi (2015), p.49; Fang (2015), p.239
[57] Hall (1979), p.272
[58] See Gold et al. (2001), p.186
[59] See Karlsson et al. (2001), p.104 in Fischer et al. (2001)
[60] See Teece (1981), p.84; Harrison et al. (1996), p.66; Karlsson et al (2001) p.104 in Fischer et al. (2001)

advantage, the codification of entrepreneurial knowledge is very rare and often kept as business secrets.[61]

Knowledge and other intangible assets are the main sources of competitive advantage in economically leading countries. Hence, if knowledge is easily imitable and tradable in a competitive market, it no longer characterises as a competitive advantage of the firm and becomes information.[62] Furthermore, a relationship between the codification of knowledge and its transfer costs can be established. Transfer costs in this regard refer to the cost of labour that is required for an effective transfer process of knowledge.[63] Additionally, if receiving and transmitting entities share similar characteristics, for example operating in the same industry, the ease of transfer of codified technology is significantly enhanced.[64] The more knowledge or experience is codified, the easier and more cost-efficient it can be transmitted. Teece defines codification as “the transformation of experience and information into symbolic form.”[65] Von Hipple and Teece both characterise tacit knowledge as “sticky knowledge” or “sticky asset” due to its high cost of transfer.[66] Hence, acquiring and transferring such knowledge is slow and often leads to ambiguities and interpretation errors. However, the latter can be significantly reduced by face-to-face communication.[67]

Consequently, transferring tacit knowledge requires social interactions.[68] Tacit knowledge has been acknowledged as the central ‘key to innovation and value creation’, emphasising the need for geographic proximity to further access tacit knowledge sources.[69] Considering the learning economy research stream, socially organised learning has significantly grown in importance. Knowledge creation depends upon the social interactions and knowledge flows between firms, customers, suppliers and other organisations.[70] Considering that

[61] See Harrison et al. (1996), p.66; Karlsson et al. (2001), p. 104-105 in Fischer et al. (2001)
[62] See Teece (1998), p.67 and p.76-77
[63] See Teece (1981), p.84
[64] See Teece (1981), p.82-83
[65] Teece (1981), p.83
[66] See von Hippel (1994), p.430; Teece (1998), p.67; Gertler (2003), p.79
[67] Teece (1981), p.83; Gertler (2003), p.79
[68] See van der Panne (2004), p.594
[69] See Gertler (2003), p.76
[70] See Lundvall et al. (1994), p.41; Gertler (2003), p.79

different knowledge owners possess different types of knowledge, experience initiates and enhances communication and a mutually beneficial knowledge transfer.[71]

Accessing such knowledge beyond these local cluster boundaries is rather rare.[72] Following this logic, knowledge spillovers are geographically bounded and hence require proximity to be taken advantage of.[73] Hence, an impetus is created for spatial co-location of firms to benefit from knowledge being emitted locally by other industry firms.[74] Furthermore, this line of argument explains the different paces of economic prosperity across different regions as the concept of knowledge spillovers presents the main explanatory element.[75]

This local phenomenon can be described as *knowledge networks*. These networks consist of multiple nodes and links connecting them. Each node represents one particular spatial actor, for example, a firm, a research organisation, a university or even specific individuals. Therefore, the nodes are characterised by their knowledge-creation function. In contrast, the links represent the network's communication and transportation channels of knowledge. In addition to patents and business secrets, the perspective of geographic proximity adds a further protection mechanism to knowledge exchange.[76]

It can be argued that in particular, the close-quarter environment of cities fosters knowledge spillovers and the creation of such knowledge networks as ideas and knowledge can flow quickly from one individual knowledge holder to another.[77] Scholars such as Jacobs and Lucas argue even one step further. Jacobs emphasises the interactions between individuals in close-quarter environments are the main driver of idea generation and innovation.[78] Learning from one another and continuous improvement enhances productivity. These increased returns of agglomeration are the only reason why the concept of a city exists

[71] See Teece (1981), p.82
[72] See Karlsson et al. (2001), p.102 in Fischer et al. (2001)
[73] See Feldman et al. (1999), p.410; van der Panne (2004), p.594
[74] See Beaudry et al (2009), p.320
[75] See Karlsson et al. (2001), p.102 in Fischer et al. (2001)
[76] See Karlsson et al. (2001), p.105 in Fischer et al. (2001)
[77] See Glaeser et al. (1992), p.1127
[78] See Jacobs (1969), p.85

despite disadvantages such as higher rents and absorption of unreasonable amounts of time for ordinary activities such as moving goods around.[79]

3.2 Marshall-Arrow-Romer (MAR) or Jacobs – who is right about spatial externalities?

Considering the neoclassical model of economics, it has been argued that technological change is exogenous, implicating an equal economic starting position for all countries. However, a cross-country divergence can be observed, implying a failure of the so-called catch-up effect. Subsequently, a new research stream named evolutionary economic geography (EEG) has emerged, rejecting the neoclassical model and its optimal decision-making and equilibrium analyses.[80] The EEG research stream tries to answer the most pressing question in economic geography: "Why do some regions or countries continue to significantly outperform others?"[81] Hence, alternative models had to be developed in conjunction with knowledge spillovers as a reference to technological development.[82]

One explanation has been proposed by Glaeser et al. (1992), who utilise the theories of Marshall (1890), Arrow (1962) and Romer (1986) to consolidate them to the MAR model, which perceives specialisation as the main source of knowledge spillovers. Opposed to the MAR model, Jacobs (1969) proposes that diversity leads to knowledge spillovers. Independent of the contradiction, both theories receive great support and propose explanations of inter-cluster knowledge creation and diffusion.[83] Despite the importance of knowledge spillovers being unanimously agreed upon, academics argue in which spatial context (MAR vs Jacobs) knowledge spillovers occur between firms.[84]

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[79] See Jacobs (1969), p.85; Glaeser et al. (1992), p.1127; Lucas (1993), p.252
[80] See Boschma et al. (2018), p.213-214 in Clark et al. (2018)
[81] Galliano et al. (2015), p.1841
[82] See Romer (1994), p.4
[83] See Bathelt et al. (2004), p.38; Wixe (2015), p.2055
[84] See Karlsson et al. (2001), p.102 in Fischer et al. (2001); van der Panne (2004), p. 594

3.2.1 Marshall-Arrow-Romer (MAR) externalities (localisation externalities)

According to Krugman, the MAR model consists of three major elements: (a) technological spillovers, (b) supply of shared inputs and (c) a local highly specialised labour force.[85]

Considering the element of technological spillovers, Marshall, Arrow and Romer's view on knowledge is closely linked. Marshall perceives a local agglomeration of industry firms as a facilitator for knowledge spillovers within a given industry. Arrow regards knowledge as a means to an end in the production process, where learning equals work experience. Romer states that new knowledge is accumulated by employing resources to research. The newly generated knowledge is then reinvested into the firm by new technologies and thereby internalised, leading to accelerated growth.[86] Additionally, the accumulation of knowledge is always incentivised, as Arrow and Romer perceive knowledge as a "capital good with an increasing marginal product."[87] However, competition is considered negative for the economy due to the free rider effect minimising the incentives to innovate. Arrow and Romer perceive technology and knowledge as non-rival goods, and neither account for any inter-industry knowledge transfer.[88]

Romer argues that the level of per capita capital stock converges over time. Hence, the growth per capita output is a decreasing function leading to lower returns on investments. Therefore, the main argument of the MAR model and economic growth is centred around intra-industry knowledge spillovers in geographic proximity.[89] Romer argues that the generation of new knowledge will always have positive external effects on other market participants as the knowledge accumulator will not be able to keep knowledge perfectly for themselves.[90] The local concentration of industry firms facilitates the exchange of industry knowledge and enhances the degree of specialisation within the local knowledge pool. This, in return, encourages further communication and knowledge exchange of processes and technological know-how.[91] It is assumed that such knowledge externalities are bounded

[85] See Krugmann (1991a), p.36-37; Schiele et al. (2008), p.31; Lerch (2009), p.15
[86] See Romer (1986), p.1007; Glaeser et al. (1992), p.1127
[87] Romer (1986), p.1006
[88] See Wixe (2015), p.2055
[89] See Glaeser et al. (1992), p.1127
[90] See Romer (1986), p.1003
[91] See Glaeser et al. (1992), p.1127; Feldman et al. (1999), p.410

spatially and only occur between firms of the same or closely related industries.[92] These particular types of knowledge externalities are acknowledged as specialisation externalities.[93]

The MAR model assumes a superior role of a monopoly contrary to competition with regard to innovation activities as the ideas and innovations can be better protected, and the sole benefits remain within the innovators.[94] In this view, the monopoly is not restricted to a single firm. The monopoly rather refers to the specific local industry as a collective. Within the collective, intra-industry technological spillovers are present and desirable to accelerate growth.[95] Due to its competitive approach, the MAR model can be closely linked with the Schumpeterian view.[96]

The second line of argument is concerned with the supply of shared inputs. Such shared inputs enable economies of scale, providing an important source for localisation economies.[97] Additionally, the outlined argument of specialisation accelerates the firms' profits from economies of scale further and thus, raising the return on investment per capita.[98] Furthermore, economies of scale incentivise a further concentration of producers. Additionally, suppliers will co-locate next to their customers due to the demand concentration and transaction costs. Hence, such an industrial concentration tends to be self-sustaining.[99] However, Krugman argues that the initial localisation phenomenon is triggered by a rather ‘accidental event’ meaning a random location choice by the first moving firm in the past.[100] This starting point is not interesting to economists, but the cumulative process and its longevity are. Hence, Krugman draws two implications: (a) the described self-sustaining processes are pervasive, which in return means that the rather famous example of Silicon Valley is not unique at all, and (b) the skilled labour pool and supply of shared inputs

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[92] See Feldman et al. (1999), p.412; Beaudry et al. (2009), p.318-319
[93] See van der Panne (2004), p.594; Frenken et al. (2005), p.9
[94] See Glaeser et al. (1992), p.1127; Feldman et al. (1999), p.412-413; van der Panne (2004), p.595
[95] See Beaudry et al. (2009), p.319
[96] See Glaeser et al. (1992), p.1127
[97] See van der Panne (2004), p.594; Beaudry et al. (2009), p.319
[98] See Henderson (1997), p.450
[99] See Krugman (1991a), p.98
[100] See Krugman (1991a), p.66-67

are critical regardless of the potential for technological externalities.[101] Additionally, the local concentration of industry firms leads to a reduction in transportation costs.[102]

Another main reason for firms to co-locate at a particular place is the existence of a labour pool with specific skills.[103] Further co-locating firms will create local industrial centres, which will lead to a growing, highly specialised local labor pool. This mutually benefits employees and firms as employees are able to freely change their employer without the requirement of relocation. Additionally, a local industry concentration provides a safety net for workers in case of business uncertainty and layoffs within one firm.[104] Firms, in contrast, benefit from this human capital turnover due to the inflow of new ideas. However, Combes and Duranton raise the argument of potential "labour poaching" from a firm's workforce by another local firm. When a worker is considered a strategic employee, a poach by another firm appears as a cost due to the loss of a valuable employee. A possible solution for employers is increasing their strategic employees' salaries.[105]

Furthermore, labour mobility is considered a significant contributor to knowledge diffusion, new combinations of knowledge and linkages between firms which lead to further knowledge spillovers.[106] Additionally, the training and recruitment costs are reduced due to the proximity of the workforce.[107] This is particularly important as labour is considered a heterogenous input with varying migration costs across regions and time.[108] Academics argue that a larger labour pool provides knowledge and experience spillovers between individuals leading to a faster build-up of an individual's skills and higher productivity per individual.[109]

[101] See Krugman (1991a), p.62
[102] See Beaudry et al. (2009), p.319
[103] See Krugman (1991a), p.65; Krugman (1991b), p.484-485; Beaudry et al. (2009), p. 319
[104] See Mukkala (2004), p.2420; Beaudry et al. (2009), p.319
[105] See Combes et al. (2006), p.3
[106] See Power et al. (2004), p.1027; Beaudry et al. (2009), p.319; Wixe (2015), p.2054
[107] See Mukkala (2004), p.2420
[108] See Almeida (2007), p.67
[109] See Beaudry et al. (2009), p.331

Overall, the strength of localisation externalities depends on the size of the industry agglomeration. The greater the number of co-located firms and the larger the local labour pool, the higher the likelihood for localisation externalities to occur and benefit from.[110]

3.2.2 Jacobs externalities (urbanisation externalities)

Contrary to MAR, Jacobs strongly believes that the most valuable knowledge spillovers are inter-industry spillovers and thus advocates a locally diverse industry structure to accelerate growth and innovation.[111] Since this variety of industries can only be observed in cities, she views cities as the main source of new knowledge and innovation.[112] Additionally, in her book *The Economy of Cities,* she emphasises the role of competition in stimulating the need to innovate and speed up innovation adoption.[113] However, Jacobs does not refer to competition within product markets. Competition, from her point of view, rather deals with firms competing for economic agents (labour), which provide access to new ideas and knowledge.[114] Additionally, increased competition across companies leads to specialisation in at least locally demanded niches.[115]

This view is strictly opposed to MAR[116] but also supported by Harrison et al., who argue that a diverse local industry structure leads to a wider range of skills in the local work force. Thus, an exchange of labour facilitates the prevalence and adoption of new knowledge and technology.[117]

Furthermore, existing transportation and frequently utilised communication channels, accessibility to specialised services, and geographic proximity foster the generation of such urbanisation externalities, also referred to as Jacobs or diversification externalities.[118] Beaudry and Schiffauerova argue for establishing a "science base as a communication

[110] See Frenken et al. (2005), p.10
[111] See Glaeser et al. (1992), p.1128; Feldman (2009), p.15; Wixe (2015), p.2055
[112] See Beaudry et al. (2009), p.319; Wixe (2015), p.2055; Caragliu et al. (2016), p.92-93
[113] See Glaeser et al. (1992), p.1128; Beaudry et al. (2009), p.319
[114] See Feldman et al. (1999), p.413; van der Panne (2004), p.595
[115] See Feldman et al. (1999), p.413
[116] See Wixe (2015), p.2055
[117] See Harrison et al. (1996), p.66
[118] See Beaudry et al. (2009), p.319

channel which facilitates the exchange and cross-fertilisation of existing ideas and the generation of new ones across disparate but complementary industries."[119] This element will further amplify urbanisation (Jacobs) externalities by reducing absorption costs resulting in higher growth rates.[120]

Additionally, closely linked industries which conduct business on related technologies benefit from technological spillovers and imitation of best practices from the other industry.[121] In fact, knowledge externalities occurring from urbanisation are accelerated when the local knowledge stock reaches a high degree of complexity. This particular large knowledge stock becomes quasi-public and enables a modularisation of heterogenous and complementary technological knowledge, which can be deployed across multiple industries.[122] This exchange of complementary knowledge due to a diversified local industry structure provides a higher return to new economic knowledge and fosters further growth.[123]

Concluding, Jacobs puts the composition of the local cluster as the central argument and, thus, diversity as the main mechanism of accelerated economic growth.[124]

Neither Jacobs nor the MAR model can be considered wrong or right as the literature remains inconclusive whether localisation or urbanisation externalities favour innovative local activity.[125] Both theories have strengths and weaknesses. In summary, agglomeration advantages can be linked to three different mechanisms.

[119] See Beaudry et al. (2009), p.319
[120] See Glaeser et al. (1992), p.1128; Antonelli (2017), p.3
[121] See Combes (2000), p.332 and p.350; Beaudry et al. (2009), p.319; Wixe (2015), p.2055
[122] See van der Panne (2004), p.595; Antonelli et al. (2017), p.3
[123] See Feldman et al. (1999), p.410; van der Panne (2004), p.595
[124] See Glaeser et al. (1992), p.1128; Feldman et al. (1999), p.412; Antonelli (2017), p.3
[125] See van der Panne (2004), p.593

1. Agglomeration of firms provides possibilities for sharing of indivisible goods, other assets, investments and thus risk mitigation.[126]
2. Agglomeration of firms attracts employees and vice versa, providing a market for highly skilled employees. This further enhances the quality of the labour market, which in return acts as a catalyst for productivity, innovation and growth.[127]
3. Urban environments naturally attract a larger number of firms and people. Thus, the potential for knowledge spillovers and human capital accumulation is significantly increased.[128]

3.3 Multiple scientific disciplines adding perspectives on agglomeration theory leading to enhanced complexity

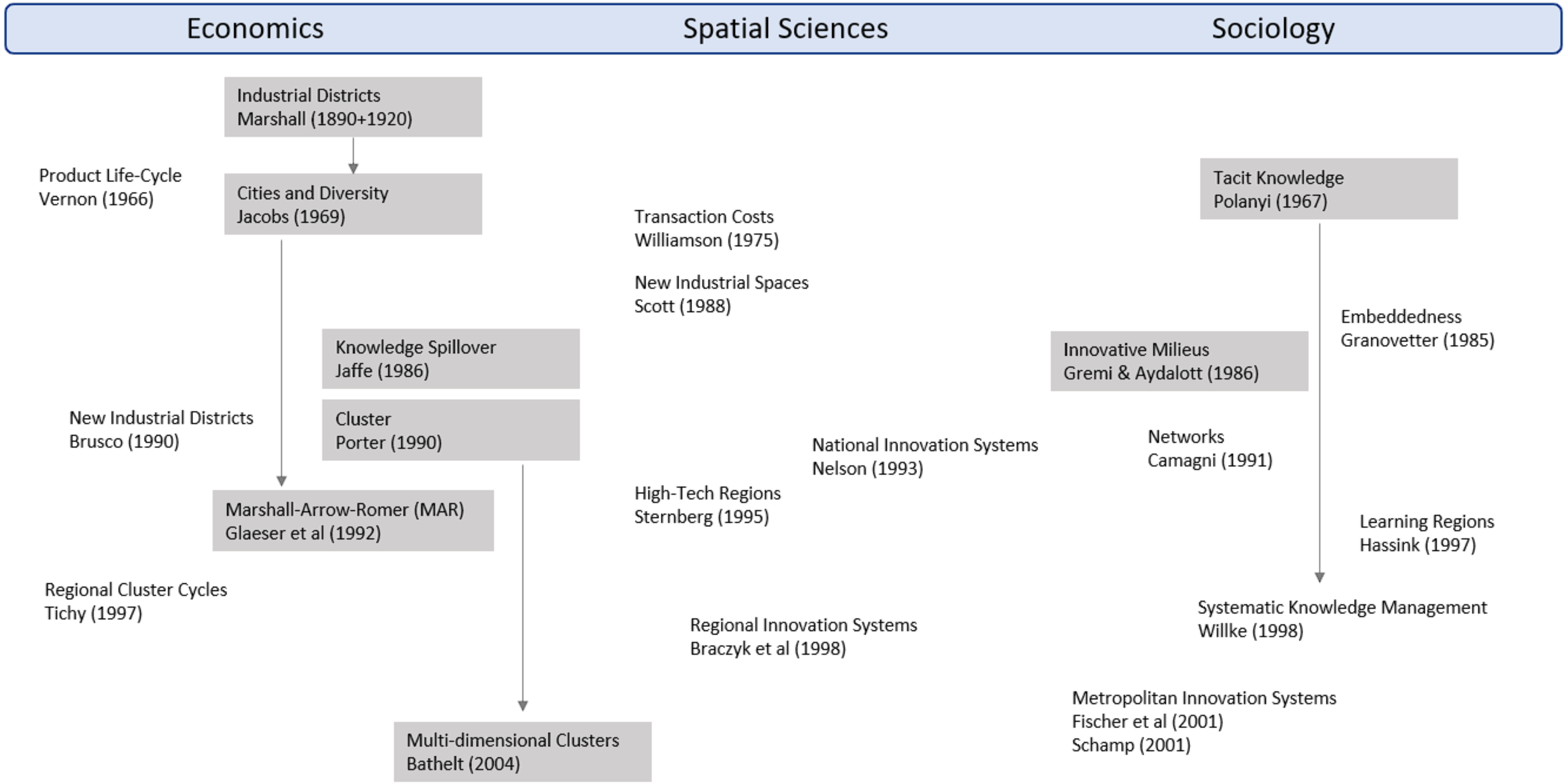
Based on Marshall's theories, a large variety of different theoretical approaches by different scientific disciplines have added their valuable perspectives on agglomeration theory. Economists such as Jaffe et al. (knowledge spillover)[129], Jacobs (diversity)[130], Porter (cluster)[131] , and Bathelt et al. (multidimensional cluster approaches)[132] have significantly impacted the economic knowledge of spatial economic clusters. Spatial scientists like Williamson (transaction costs)[133], Sternberg (high-tech regions)[134] and Nelson (national innovation systems)[135] , as well as sociologists like Polanyi (tacit knowledge)[136] and Camagni (networks),[137] added non-economic perspectives on the clustering phenomenon. However, it can be argued that the involvement of multiple scientific fields for the underlying cluster concepts has led to the homogeneity of cluster definitions shown in

[126] See Duranton et al. (2004), p.2067 in Henderson et al. (2004)
[127] See Duranton et al. (2004), p.2086 in Henderson et al. (2004)
[128] See Duranton et al. (2004), p.2098 in Henderson et al. (2004)
[129] See Jaffe et al. (1993)
[130] See Jacobs (1969)
[131] See Porter (1990)
[132] See Bathelt et al. (2004)
[133] See Williamson (1975)
[134] See Sternberg (1995)
[135] See Nelson (1993)
[136] See Polanyi (1967)
[137] See Camagni (1991) in Boyce et al. (1991)

chapter 2. A chronological perspective on the development of these theories has been provided by Thomi et al. [138]

[138] See Thomi et al. (2008), p.74

Figure 1: Conceptual diversity of the topic of space, knowledge and economic development[139]



Source: Based on Thomi et al (2008), p.74

[139] The highlighted theories are considered in this thesis

Within the past 100 years, various concepts have been developed and added to cluster theory. The complexity has further increased after the publication of Porter's work[140] , which has drawn significant interest from economic geographers and, as such, is considered the most influential work on cluster theory.[141] Another important reason for the various conceptions is the different perspectives and levels of analysis.[142]

Despite the different perspectives and theories, scholars agree that the pure agglomeration of firms is not a sufficient criterion for the classification as a cluster.[143] Scholars emphasise four core cluster determinants: (1) concentration or agglomeration of firms, (2) cooperation, (3) competitors and (4) competition.[144]

In 1990, the agglomeration economies theory evolved into another literature stream which is widely known as cluster theory. One of the most influential academic scholars, Michael Porter acknowledges and values both MAR' and Jacobs' theories and used both concepts' strengths to develop his model of competitive nations and clusters, applying it on a national and regional scale.[145] Porter's contributions provided the core principles of nowadays cluster literature stream by combining both perspectives of the existing agglomeration economy theory and adding further elements e.g. entrepreneurship. Hence, Michael Porters work will be thoroughly reviewed in the next chapter due to its importance for the understanding of cluster theory.

[140] See Porter (1990)
[141] See Martin et al. (2003), p.5
[142] See Kiese (2008), p.14; Kaminski (2009), p.9
[143] See Martin et al. (2003), p.10; Jonas (2014), p.16
[144] See Porter (1991), p.157; Sternberg (2005), p.120 in Cernavin et al (2005); Jonas (2014), p.17
[145] See Porter (1990), p.156

4 Porter: A new paradigm for the development of economic prosperity

In 1990, Michael Porter published his book *The competitive advantage of nations* with a macroeconomic perspective on the competitiveness of nations and what distinguishes nations from one another. Porter's central question to be answered in his work is, "Why do firms based in particular nations achieve international success in distinct segments and industries?"[146]

Observing and analysing multiple nations and industries, Porter concluded that firms and not nations compete in international markets and, as such, create and sustain the competitive advantage of nations.[147] Due to the continuously changing economic environment stemming from changing competition, technological change, comparable factor endowments and globalisation, Porter calls for a new strategic paradigm for firms.[148]

Porter's argument about *changing competition* deals with the competition for skilled workers. While production has been significantly more labour-intensive and less skill-intensive in the past, nowadays, industries depend on workers' special abilities and knowledge. Additionally, Porter argues that the most important industries to national productivity are the industries that develop and require sophisticated technologies, which in return require highly trained employees. Hence, the role of factor cost has been diminished over time.[149]

Second, Porter refers to *technological change* as another important role in economic development. While in the past, a majority of industries have developed around economies of scale, consumer behaviour has changed and let to more differentiated products incorporating different buyer needs. Various multi-facetted technological advancements such as microelectronics and advanced materials have significantly increased productivity

[146] See Porter (1990), p.18
[147] See Porter (1990), p.33
[148] See Porter (1990), p.13-14
[149] See Porter (1990), p.13

and, thus, economic imbalances between nations.[150] Furthermore, technological change can nullify prior competitive advantages.[151]

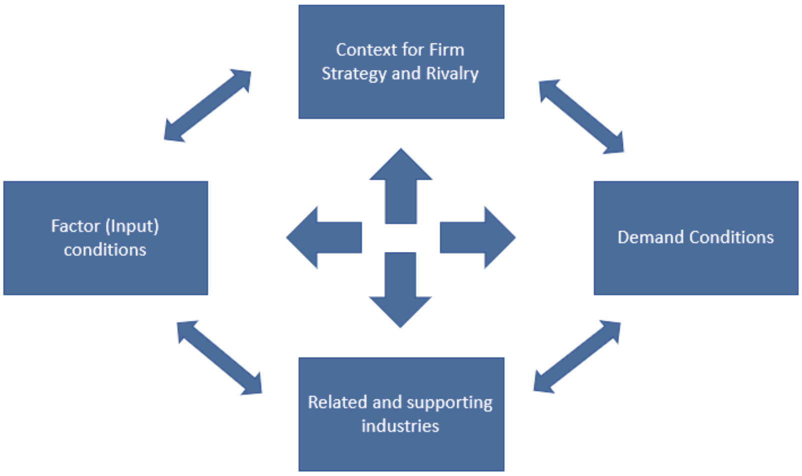
Thirdly, the role of *comparable factor endowments* has been subject to an alteration. Developed nations provide the education and basic skills for their citizens to occupy jobs in different industries. Hence, this factor advantage has been weakened over time.[152]

Lastly, Porter argues that globalisation calls for a new perspective on economic development. Competition has internationalised independent of the industry or sector. Furthermore, firms and nations source resources globally and utilise low-cost factors by localising in other countries. These factors have decoupled the firm from their home nations' factor endowment.[153] However, despite the increased mobility of input factors, the effectiveness and efficiency in deployment is the distinction factor for international success.[154]

From his analysis, Porter came up with four determinants for national advantages which he concluded to his national diamond model.[155] These determinants, their interactions and interdependence forge the likelihood, direction, speed of improvement and innovation by the national's firms in an industry.[156] The diamond model and its interconnections are presented in Figure 2.

[150] See Porter (1990), p.14
[151] See Porter (1990), p.167
[152] See Porter (1990), p.14
[153] See Porter (1990), p.14
[154] See Porter (1990), p.15
[155] See Porter (1990), p.131
[156] See Porter (1990), p.173

Figure 2: Sources for competitive advantages



Source: Porter (2000), p.20

Porter perceives the diamond as a system which is constantly in motion and restructuring itself due to shifting circumstances.[157] This mutual dependence and reinforcement of the determinants are at the core of the diamond model. A competitive advantage can only be maintained when its sources are widened and upgraded. Furthermore, Porter puts significantly more emphasis on dynamic advantages (innovation rate, early mover advantages and competitive pressure) in comparison to static advantages (factor costs, home market size). However, such a system needs to be unique, meaning it cannot be penetrated from the outside or duplicated.[158]

4.1 Application of the diamond model towards regional clusters

In addition to the diamond model, Porter acknowledges that its systemic nature stimulates the clustering of a nation's competitive industry, which has been observed across all nations in his analysis.[159] In fact, the clustering phenomenon is ubiquitous. Thus, industrial clusters

[157] See Porter (1990), p.144
[158] See Porter (1990), p.147
[159] See Porter (1990), p.148-149

present as a distinctive central feature of advanced national economies. [160] His observation of industry clusters and their impact on a nation's competitiveness has raised significant interest in the concept of clusters by academics and practitioners. Ketels et al. revealed a significant increase in cluster initiatives since Porter's publications.[161]

Porter defines clusters as linked firms and institutions operating in a specific sector in a geographical space. The cluster concept by Porter is not limited to a traditional industry category due to the inclusion of complementarities and knowledge spillovers related to other industries.[162] Hence, one could argue that Porter adds the diversity element of Jacobs to his competitive cluster concept, providing a more holistic model.

According to Porter, the cluster phenomenon emerges directly from the four determinants of the diamond model and can be considered a symptom of their systemic character.[163] However, Porter also acknowledges that the cluster is never fully in place as it is a continuous evolutionary process. Usually, one competitive advantage within a single determinant provides the initial spark for cluster development. Porter perceives (1) factors of production, (2) related and supporting industries and (3) demand conditions as the most impactful starting determinants.[164] Once a cluster starts to develop, it will constantly attract additional input factors, thus increasing the role of the other determinants.[165]

Despite being located in geographic proximity to one another, information and knowledge might not flow fluently across cluster members due to conflicting economic interests. According to Porter, five accelerators for information flows should be coordinated and established within a cluster.[166]

- Personal relationships due to schooling or military services
- Ties through the scientific community or professional associations
- Community ties due to geographic proximity
- Trade associations encompassing clusters

[160] See Porter (1990), p.149
[161] See Ketels et al. (2006), p.9
[162] See Porter (2000), p.18
[163] See Porter (1990), p.149
[164] See Porter (1990), p.159-160
[165] See Porter (1990), p.159
[166] See Porter (1990), p.153

- Shared norms of behaviour, such as a belief in continuity and long-term relationships

Furthermore, Porter argues for goal alignment among cluster members through the following mechanisms:

- Family or quasi-family ties between firms
- Common ownership within an industrial group
- Ownership of partial equity stakes
- Interlocking directors
- National patriotism

The consequent connections between firms and institutions enable a dynamic level of innovation[167] and raise productivity.[168] The vertical (related and supporting industries) or horizontal (competitors and complements) competitive economic relationships tie the cluster together.[169] The competitive environment increases productivity but also creates knowledge spillovers at the same time. Thus, cluster benefits flow forward, backwards and horizontally.[170]

Porter agrees with the MAR specialisation hypothesis of knowledge spillover occurring mainly within vertically integrated industry structures. However, he emphasises that competition does not decrease innovation. [171] In contrast, Porter argues for domestic rivalries which occupy a direct role in stimulating improvement and innovation.[172] Additionally, close proximity enhances the likelihood of exposing imbalances and inefficiencies, which increases the probability of cluster members counteracting.[173] Thus, a vibrant entrepreneurial spirit is a prevalent phenomenon within clusters.[174]

Competition incentivises firms to conduct R&D activities leading to an increased likelihood of innovation despite the individual innovation providing a lower return potentially.[175] Thus,

[167] See Padmore et al. (1998), p. 628; Porter (2000), p.19
[168] See Porter (1998b, p.13; Henderson (2003), p.23-24, Schiele (2003), p.35-36
[169] See Porter (1990), p.149; Hanson (1994), p. 1266
[170] See Porter (1990), p.151
[171] See Beaudry et al. (2009), p.319
[172] See Porter (1990), p.143
[173] See Porter (1990), p.157
[174] See Porter (1990), p.164
[175] See Combes (2000), p.334; Wixe (2015), p.2055

a competitive regional environment opposed to a local monopoly puts pressure on cluster firms, which in return leads to higher productivity levels, more rapid adoption of innovations and overall enhances the cluster's competitiveness.[176]

Subsequently, competition leads to a higher degree of specialisation within cluster members.[177] This, in turn, leads to transferable skills, the development of related technologies and additional shared infrastructure.[178] Hence, local competition creates an iterative cycle of knowledge spillover acceleration.[179]

This iterative circle can be further enhanced by considering additional factor conditions, such as universities and independent research institutions co-located within the cluster. Porter argues, along with Batten et al. and Kobayashi, that their basic and applied research will further accelerate the knowledge flow among cluster members and create a local knowledge network.[180] This local inimitable and non-transferable knowledge network provides a significant competitive advantage as outside competitors lack such a high degree of specialised knowledge.[181]

Within the context of clusters, Porter argues that sophisticated local customers impact the demand conditions. These local customers provide valuable insights, transfer important demand information to the cluster firms and continuously engage in an exchange about technological development and applications.[182]

In summary, Porter highly emphasises cluster membership as a mechanism for firms to overcome inflexibility and inertia and retain diversity.[183] In addition, the individual determinants of his diamond model and their mutual reinforcement are accelerated by geographic proximity.[184] The mutually beneficial cluster structure accelerates the generation of externalities, providing higher growth rates over other geographical accumulations of

[176] See Glaeser et al. (1992), p.1128; Wixe (2015), p.2055; Caragliu (2016), p.93
[177] See Porter (1990), p.157
[178] See Porter (1990), p.151
[179] See Feldman et al. (1999), p.413
[180] See Porter (1990), p.157; Kobayashi (1995), p.130 in Batten et al (1995)
[181] See Teece (1998), p.67 and p.76-77
[182] See Porter (1990), p.157
[183] See Porter (1990), p.151 and p.173
[184] See Porter (1990), p.157

firms for a number of years or even decades.[185] Porter acknowledges and values both MAR' and Jacobs' theories and uses both concepts' strengths to develop his model, applying it on a national and regional scale.[186]

4.2 Porter has continuously been criticised for his concepts, but the underlying theory remains sufficient.

Throughout his academic career, Porter has been criticised for his cluster concept. One of the main reasons is the multiple ambiguous cluster definitions compiled by Porter as shown in Table 3.[187]

Table 3: Cluster definitions by Porter[188]

Porter (1998a) p.78 Porter (2000) p.15	"A cluster is a critical mass in one place – of unusual competitive success in particular fields. "
Porter (2000a) p.15 Porter (2000b) p.253	"Clusters are geographic concentrations of interconnected companies, specialised suppliers and service providers, firms in related industries, and associated institutions (for example, universities, standards agencies, and trade associations) in particular fields that compete but also cooperate."
Porter (2001) p.7	"Clusters are geographically close groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills."
Porter (2003) p.562	"We define a cluster as a geographically proximate group of interconnected companies, suppliers, service providers and associated institutions in a particular filed, linked by externalities of various types."
Porter (2006) p.226	"A cluster is a form of network that occurs within a geographic location, in which the proximity of firms and institutions ensures certain forms of commonality and increases the frequency and impact of interactions."

[185] See Porter (1990), p.161 and p.164; Beaudry et al. (2009), p.319;
[186] See Porter (1990), p.156
[187] See Lerch (2009), p.27
[188] Own summary of Porter's academic cluster definitions

In general, Porter argues that a cluster consists of interconnected companies and related institutions whose actions are partially linked to one another. Additionally, Porter acknowledges the importance of linkages or (social) networks in which cluster firms are embedded. [189] Furthermore, the role of shared technologies and skills has been added later, which is directly linked to the central feature of knowledge spillovers. [190] In spite of knowledge sharing, Porter emphasises the idea of coopetition (competition while cooperating) in his definitions as well. Later on, Porter adds the element of externalities to his definition.

Despite clusters being a phenomenon of spatial proximity, Porter avoids providing a clear definition of what spatial proximity refers to in the context of a cluster.[191] The lack of geographical precision is a major point of criticism and has led to various cluster definitions within the scientific community.[192] Porter argues that cluster borders are a “matter of degree and involve a creative process”.[193] Boundaries vary dependent on the analysed industry and their respective dependency on spillovers to productivity and innovation.[194] Hence, Porter’s clusters could obtain the size of a city area, the entire city, a nation or even cross-national borders.[195] One reason for this wide scope is due to Porter’s changed research focus from a national macroeconomic perspective to a microeconomic perspective of the firm.[196]

This openness and flexibility of Porter’s concept have been central to his critics.[197] It can be argued that cluster success depends not solely on the interconnectedness of geographically embedded firms.[198] Local infrastructure and the access to external markets need to be included in the discussion.[199] Additionally, Porter’s four determinants are neither new nor unexpected.[200]

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[189] See Porter (1999), p.226 and p.238
[190] See Porter (1999), p.238
[191] See Kiese (2008), p.10
[192] See Martin et al. (2003), p.12
[193] See Porter (2000), p.255
[194] See Porter (2000), p.255
[195] See Porter (1999), p.209
[196] See Kiese (2008), p.10
[197] See Lerch (2009), p.29
[198] See Padmore et al. (1998), p.629
[199] See Padmore et al. (1998), p.639
[200] See Rugman et al. (1993), p.20

Despite several academics emphasising that the agglomeration economies literature provides implications specifically for policy makers, governments are treated as exogenous in Porter's diamond framework. Several authors have challenged this view. The government's allocation function of public goods such as airspace is emphasized by Padmore et al.[201] Hence, the devaluation of the role of government in Porter's economic view is central to the critique. Padmore et al. argue that their GEM framework adds a more granular perspective which is more suitable for analysis on a regional level.[202] Concluding, the role of governments is inadequately depicted within the factor condition in the initial diamond model.

The inevitable impact of governments on the microeconomic level has been revised by Porter in 2000.[203] Nevertheless, he emphasises that cluster development should be driven by market forces and not government policies.[204] Governments should act as a coordinator with minimal interference with fundamental market factors.[205] Interference should be restricted to the removal of legislative hurdles or comparable inefficiencies.[206] However, practical policies always lead to favoring winners or backing losers.[207]

Furthermore, Hospers et al. found that governments have never been influential in the formation of clusters. However, they propose a concept of cluster marketing, referring to advocating its distinct features to attract external investments after cluster emergence.[208] Consequently, the central aspect of the regional cluster model becomes the inclusion of external firms and therefore increasing local competition and human capital to stimulate knowledge spillovers and support innovation processes.[209]

However, the major point of criticism towards Porter is the neglection of the social and relational dimensions.[210] Steinle et al. refer to these social and relational dimensions as the software of clusters. Porter focuses on the hardware of clusters, referring to the local firms

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[201] See Padmore et al. (1998), p.635
[202] See Padmore et al. (1998), p.633
[203] See Porter (2000), p.16
[204] See Porter (2000), p.26
[205] See Wolf (1990), p.5; Hospers et al. (2009), p.295
[206] See Porter (2000), p.26
[207] See Hospers et al. (2009), p.295
[208] See Hospers et al. (2009), p.296-298
[209] See Porter (2000), p.27
[210] See Martin et al. (2003), p.16; Schiele et al. (2012), p.685

and the associated externalities.[211] This dynamic perspective on clusters' social and relational dimensions is rooted in the Marshallian theories and their industrial districts.[212] In accordance with the Marshallian theories, the “innovative milieu” refers to a set of dynamic and connected firms in a spatial context that enables a localised collective learning process.[213] This differs from Porter by emphasising the local social relations that are fundamental for the generation and diffusion of knowledge.[214] Porter argues that cluster benefits stem from knowledge spillovers and cooperation[215] but fails to provide further details on the processes to foster knowledge spillovers.[216]

Despite all these arguments, criticism should not only be directed towards Porter. Within over thirty years of cluster research, the scientific community has not been able to conclude one widely acknowledged definition. Despite the criticism, Porter’s underlying thoughts and concepts remain relevant to the scientific community and provide a foundation for further research and development of cluster theories (for example, Rugman et al. (1993) and their double diamond model or Gordon and McCann (2000) with their tripartite cluster theory). A result of the variety of definitions is the various concepts developed due to the dynamic increase in cluster research after Porter’s initial publication. Their inconsequent and inconsistent applications have led to an inflationary use of the term cluster and convergence of terminology and thus caused further confusion among the scientific community.[217]

4.3 Clusters – a theoretical boost for innovation with ambiguous empirical evidence

In summary, agglomeration theory and, in particular, cluster theory both agree upon the positive theoretical effects on innovation. Jacobs, Porter and the MAR model provide valuable input for the generation of knowledge spillovers which are essential to the innovation process. However, they differ in their perception of the source of this particular

[211] See Steinle et al. (2007), p.237
[212] See Schiele et al. (2012), p.685
[213] See Camagni (1995), p.320; Schiele et al. (2013), p.685
[214] See Visser (2009), p.184
[215] See Porter (1990), p.149
[216] See Bathelt et al. (2003), p.150; Martin et al. (2003), p.16; Lerch (2009), p.30
[217] See Martin et al. (2003), p.6 and p.9; Pieper (2013), p.42; Farhauer et al. (2014), p.159

externality. However, they cannot be considered mutually exclusive. They rather provide different perspectives on what is important in their individual perception.[218]

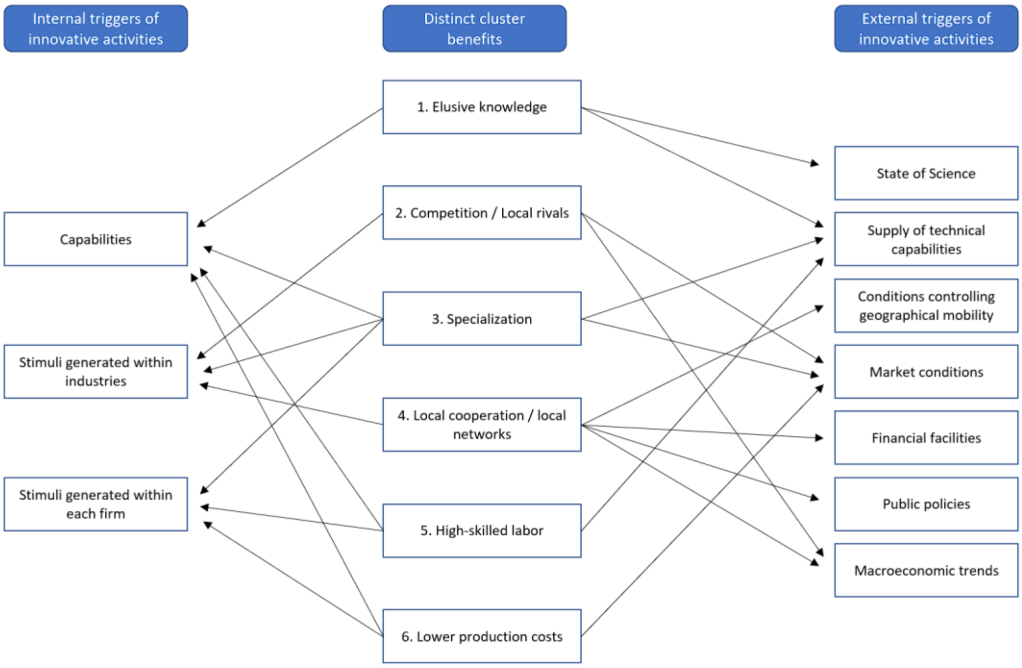
Fang et al. have concluded existing cluster literature to six distinct benefits provided by clusters that should enhance innovative activity and, thus, firm performance.[219]

1. **Elusive knowledge** as a prerequisite innovation component can be **distributed** due to close proximity within a cluster.
2. Clusters promote **competition,** and the competitive pressure of **local rivals** drives innovation efforts.
3. Due to competitive pressure, firms deepen their **specialisation** through innovations to distinct themselves from local competition.
4. **Local cooperation** and **local networks** enable risk and asset sharing, which enhances the likelihood of innovative activities.
5. Clusters attract **high-skilled labour** and thus raise the level of creativity and specialised knowledge.
6. **Lower production costs** due to shorter transportation and improved information sharing.

These six distinct benefits can be directly attributed to the internal and external triggers of innovative activities presented in Chapter 1.[220]

[218] See Glaeser et al. (1992), p.1128-1129
[219] See Fang (2015), p.240
[220] See Dosi (1988), p.1121

Figure 3: Cluster benefits and their impact on triggers of innovative activities



Source: Based on Dosi (1998), p.1121 and Fang et al. (2015), p.2015

Despite the academic consensus on the presumably positive effects of local agglomeration of firms, some scholars argue that close proximity to firm establishments also creates drawbacks.

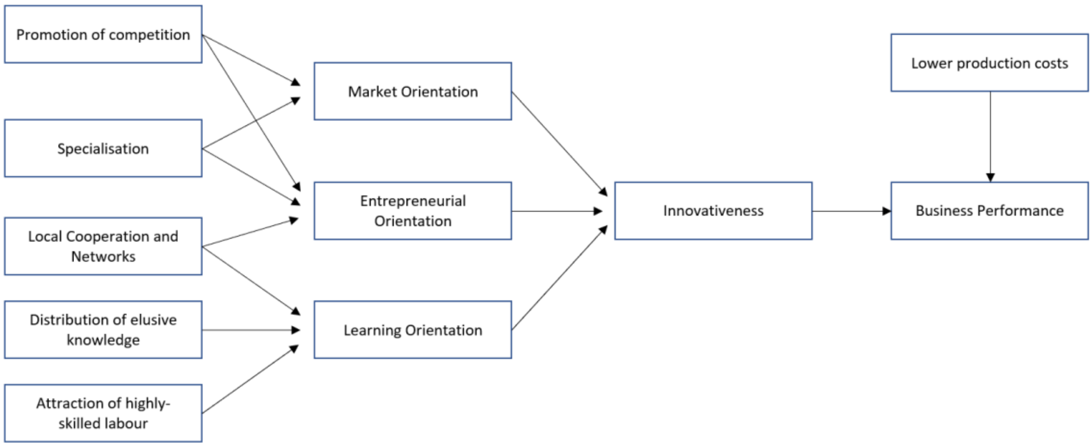
1. Overcompetition and congestion could lead to negative externalities like heavy price competition, leading to a decrease in profitability.[221]
2. The potential for knowledge spillovers could lead to the free rider effect.[222]
3. Cluster firms could be subject to the lock-in effect, which refers to the limited capabilities of firms to absorb knowledge and information from outside the cluster boundaries.[223]
4. Higher wages due to over-competition for skilled workers.[224]

[221] See Baptista (1998), p.50; See Schiele et al. (2012), p.16
[222] See Shaver et al. (2000), p.1177
[223] See Boschma (2005), p.66
[224] See Fabiani et al. (1998), p.463 in Müller et al. (1999); Schiele et al. (2012), p.16

4.4 Despite theoretical cluster benefits, empirical research remains heterogeneous.

A large body of empirical literature has been produced because of the theoretical debate of cluster promotors against cluster critics. The six distinct cluster benefits derived by Fang et al. (2015) can be directly applied to the model developed by Hult et al. (2004).

Figure 4: Cluster benefits and their impact on business performance



Source: Hult et al. (2004), p.430 and Fang et al. (2015), p.240

Figure 4 presents the transition from cluster benefits towards business performance. The triggers of innovative activities shown in Figure 3 can be attributed towards the Innovativeness. Hence, Figure 4 adds the element of market, entrepreneurial and learning orientation to the equation, all of which transition into business performance.

Several authors have empirically documented that learning and, thus, innovation and technology adoption are higher in cluster firms in comparison to non-cluster firms.[225] Additionally, a firm's profitability is positively correlated to its innovation output.[226] Hence, if a cluster firm's innovativeness is enhanced due to externalities, then its business

[225] See Baptista (2000), p.530-531; Beaudry et al. (2003), p.339; Gellynck et al. (2009), p.732;
[226] See Geroski et al (1993), p.208; Bottazzi et al. (2008), p.712

performance referring to revenue growth and profitability, should be higher in comparison to its non-cluster peers.[227]

However, empirical results of cluster and agglomeration research on firm performance are as varied as cluster definitions.

For example, Baptista analysed the UK examining the significance of spatial agglomeration externalities and increasing returns with respect to labour productivity. Spatial density of economic activity, referring to the intensity of labour, human and capital accumulation in relation to physical space, served as the proxy for increasing agglomeration returns.[228] The study showed an increase of 7% in factor productivity if employment density in a UK county was doubled.[229] Similar results with respect to total factor productivity and labour productivity were observed in France.[230]

Fabiani et al. analysed thirteen Italian manufacturing districts and revealed, on average, a two to four percentage point higher profitability measured by return on equity (ROE) and return on investment (ROI) in comparison to manufacturing firms outside districts.[231] Furthermore, they revealed a lower cost of debt for cluster firms due to the local social embeddedness of cluster firms with financial institutions.[232] Overall, Fabiani et al. conclude that cluster firms are more profitable than non-cluster firms due to higher productivity and lower cost of labour and capital.[233]

Li et al. conducted a study on the manufacturing firms in Zhejiang, China. Their research analysed the impact of shared resources of cluster firms in comparison to their respective non-cluster peers. The empirical study revealed a significantly enhanced business performance measured by return on assets and sales growth of cluster firms in comparison to their non-cluster peers.[234]

[227] See Frenken et al. (2001), p.417; Hult et al. (2004), p.431; Botazzi et al. (2008), p.711-712
[228] See Baptista (2003), p.163 in Bröcker et al. (2003)
[229] See Baptista (2003), p.174 in Bröcker et al. (2003)
[230] See Abdesslem et al. (2019), p.704
[231] See Fabiani et al. (1998), p.463 in Müller et al. (1999)
[232] See Fabiani et al. (1998), p.463 in Müller et al. (1999)
[233] See Fabiani et al. (1998), p.464 in Müller et al. (1999)
[234] See Li et al. (2012), p.376

Stojcic et al. find a 15% higher sales revenue for Croatian and Slovenian wood manufacturing clusters while also having a 2-3% higher productivity.[235] However, they acknowledge that their dataset is lacking a longer period of time and is limited to one particular industry. Thus, deriving general implications on the economic performance of cluster firms is rather limited.

Pavelkova et al. analysed the financial performance of Czech plastic and textile firms. They used return on assets and return on sales in a 10-year horizon as proxies. Their conducted empirical study did not show a significant difference between cluster firms and non-cluster firms. However, they also argue, that cluster benefits might manifest over a longer period.[236]

Braune et al. analysed French small- and medium enterprises (SMEs) and the impact of the French industrial cluster policy initiatives. Revenue, R&D expense and employment of cluster SMEs grew at higher rates. However, the research revealed that despite receiving funding for joint research projects, ROE and return on assets (ROA) of French SMEs were not positively impacted in comparison to non-cluster SMEs.[237] Thus, these French firms were not able to sustain higher profitability levels despite receiving financial support from the French government at the start.[238] Braune et al. identified that the payroll ratio increased more rapidly than the firm's revenues.[239]

[235] See Stojcic et al. (2019), p.9
[236] See Pavelkova et al. (2021), p.18
[237] See Braune et al. (2016), p.325
[238] See Braune et al. (2016), p.325
[239] See Braune et al. (2016), p.322

Table 4: Overview of empirical evidence on cluster performance

Baptista (2003), p.174 in Bröcker et al (2003)	• Increase of 7% in factor productivity if employment density in a UK county was doubled
Fabiani et al. (1998), p.463 in Müller et al. (1999)	• 2-4 %pt. raise in ROE and ROI of manufacturing firms within Italian manufacturing districts • lower cost of debt of locally embedded manufacturing firms.
Li et al. (2012), p.376	• enhanced business performance measured by ROA and sales growth of cluster firms in China
Stojcic et al. (2019), p.9	• 15% increase in sales revenue of wood manufacturing clusters in Croatia and Slovenia • 2-3% increase in productivity in cluster firms.
Pavelkova et al. (2021), p.18	• No significant difference of ROA and ROS over a 10-year period in Czech plastic and textile firms
Braune et al. (2016), p.322-325	• No positive impact on ROE and ROA of French SMEs embedded in clusters • Higher payroll ratio increase of cluster firms

In summary, the empirical literature on productivity and financial performance of cluster firms in comparison to non-cluster firms on the firm level is rather limited. Additionally, the existing empirical literature on this topic provides ambiguous results.

One of the main reasons is the various definitions and lack of a common understanding of the spatial boundaries of clusters. Thus, variations in empirical research are predictable. In other words, heterogeneity across empirical studies is large.[240]

[240] See Fang (2015), p.252

Furthermore, a majority of studies lack well-defined proxies and disaggregated data to precisely analyse spatial externalities.[241] Additionally, most studies focus on one particular region or industry. Thus, deriving general expectations of firm performance is rather challenging.[242]

Despite the geographic agglomeration of firms remaining a prevalent phenomenon in nowadays economy, the economic impact of clusters on the firm level remains still a largely unexplored field.[243] Hence, this research takes one step towards evaluating the financial performance of geographically agglomerated firms.

This research' aims to provide insights into the following research question.

Does cluster membership enhance the financial performance of firms in Germany?

Empirical findings to this question have major implications for several stakeholders. Academic researchers have developed numerous theoretical arguments for agglomeration economics and its positive externalities. However, the lack of generalised empirical research concerning the tangible financial implications of cluster firms compared to non-cluster firms provides continuous reasons for cluster critics.

Furthermore, start-up founders might consider financial benefits in their location decision-making process in addition to pre-existing resources such as agglomeration of knowledge, local labour pool and infrastructure.

Financial analysts, bankers and investors will benefit from empirical research on spatial economies. Considering the potential enhanced profitability of cluster firms, these firms would add additional value to any portfolio due to their financial superiority in comparison to their non-cluster peers.

[241] See Audretsch et al. (1996), p.630; Rigby et al. (2002), p.407
[242] See Fang (2015), p.241
[243] See Stojcic et al. (2019), p.1; Mathias et al. (2021) p.3

Hence, the objective of this paper is to measure the business performance of firms in a close geographical proximity to determine the impact of spatial agglomeration on business performance.

4.5 Exploring the financial implications of cluster firms: Hypothesis development for the financial performance of cluster firms in comparison to non-cluster peers

Company leaders continuously strive to improve their company's financial performance to gain a competitive advantage and satisfy equity and debt investors. However, a wide range of key performance indicators (KPIs) provide insights into different financial perspectives, for example, profitability, liquidity or financial efficiency.

The EBITDA margin is a well-known, commonly applied and easy-to-understand financial KPI. EBITDA does not incorporate the investment of capital (depreciation). Hence comparability independent of investment cycles across firms is possible.[244] Additionally, EBITDA is a widely applied performance indicator in debt contracting.[245] Therefore, the EBITDA margin provides a sufficient profitability indicator of a firm's operations. Cluster firms are expected to have a higher degree of innovation which positively influences a firm's profitability.[246] Hence, the EBITDA margins of cluster firms are expected to be higher in comparison to their non-cluster firms.

H1-a: The EBITDA margin of cluster firms is higher in comparison to their non-cluster peers.

The second KPI for this analysis is the total debt percentage of total assets. This particular ratio is interesting because debt provides several benefits to the firm. First, financial leverage

[244] See Rozenbaum (2019), p.514
[245] See Rozenbaum (2019), p.516
[246] See Geroski et al. (1993), p.208

has been thoroughly researched and positively impacts a firm's profitability.[247] Secondly, the firm benefits from a tax shield.[248] Thirdly, a firm's cost of capital is reduced. Additionally, Fabiani et al. revealed a lower cost of debt for cluster firms due to the local social embeddedness of cluster firms with financial institutions.[249] Consequently, the firm's cashflows are increased.[250] These increased cash flows can be used for further growth and innovation investments. However, it is important to acknowledge that a trade-off between debt benefits and increased financial risk exists.[251] Because of the higher profitability expectation of cluster firms, cluster firms are expected to have higher leverage in terms of total debt percentage of total assets compared to their non-cluster peers.

H1-b: Total debt percentage of total assets is higher in cluster firms in comparison to their non-cluster peers.

The third KPI used for this analysis will be the return on average common equity. Return on equity (ROE) is a profitability ratio which only refers to equity investors. Equity investors expect a specific return dependent on the industry. Thus, equity investors compare ROEs across the industry and determine which company is worth an investment. Because of the theoretical cluster benefits, it is expected that the ROE of cluster firms is higher in comparison to their non-cluster peers.

H1-c: Return on average common equity is higher in cluster firms compared to their non-cluster peers.

This analysis's fourth and last financial KPI is the return on capital employed (ROCE). ROCE is a profitability ratio that accounts for the total capital employed in its business

[247] See Miller (1977), p.270
[248] See Modigliani et al. (1963), p.433-434; Miller (1977), p.271
[249] See Fabiani et al. (1998), p.463 in Müller et al. (1999)
[250] See Myers (2001), p.82-83
[251] See Myers (2001), p.81; Yoon et al. (2005), p.35

operations. Hence, ROCE has a more comprehensive profitability ratio in comparison to ROE due to the inclusion of the total value of equity and debt. Hence, one major advantage is that corporations with different capital structures can be compared. With respect to the theoretical cluster benefits, an increased ROCE margin of cluster firms is expected contrary to their non-cluster peers.

H1-d: Return on capital employed is higher on average in cluster firms compared to their non-cluster peers.

5 Designing a new model for empirical cluster analysis

5.1 Fundamental data provided by financial database Thomson Reuters

The data concerning the included companies has been retrieved from the Thomson Reuters EIKON database. The following three conditions have been imposed on the data set.

At first, the geographical region of analysis is limited to Germany.

Secondly, only the respective legal entity's headquarters has been included in the data sample. Thus, each headquarter has been incorporated if a firm operates with a holding structure and multiple legal entities. This approach is in line with Audia et al. and Galliano et al., who argue that a multi-location strategy is a sufficient condition to foster learning and technology adoption between firm units.[252] However, a high-level of innovation capacity is associated with the location of the head offices, which is where the strategic decisions are taken.[253] Hence, the data sample has been limited to each respective headquarters of each individual legal entity.

Thomson Reuters EIKON database is only able to export a maximum of 5.000 companies of each given industry due to technical reasons. The two previous outlined conditions did not restrict the number of companies sufficiently, hence a third condition has been developed. Thirdly, only companies with at least 50 employees have been included. A core idea of knowledge spillovers is employees transferring between companies. Thus, a threshold of 50 employees served as the required number of employees for each firm.

The following four key performance indicators (KPIs) will serve for this analysis.[254]

- Earnings before interest, depreciation and amortization (EBITDA) margin
- Return on capital employed (ROCE) margin
- Total debt % of total assets
- Return on average common equity

[252] See Audia et al. (2001), p.97 in Baum et al. (2001); Galliano et al. (2011), p.84
[253] See Schiele et al. (2014), p.110; Galliano et al. (2015), p.1844;
[254] The definitions of each KPI can be found in the annexures on page A1

The dataset contains 20 years of financial data across 126 industries and 28.874 firms. A more detailed overview of the industries and their respective financial KPIs can be seen on page A4.

Table 5: Data overview for the empirical analysis

Number of data entries				
Number of firms	EBITDA margins	ROCE margins	Total debt % of total assets	ROE margins
28.874	83.090	123.012	78.749	104.482

5.2 Unravelling the ambiguity: Exploring scholar's diverse perspectives on spatial cluster boundaries

One of the main criticisms of existing cluster research refers to the geographical boundaries of clusters. Cluster theory remains vague in cluster identification and setting geographical boundaries. In particular, Porter has been heavily criticised for his erratic transitions from national to regional clusters. For example, Porter states that cluster boundaries "rarely conform to standard industrial classification systems, which fail to capture many important actors in competition as well as linkages across industries".[255]

Martin et al. raise the important issue that academic literature lacks clear boundaries on multiple elements.[256]

1. What is the required level of industrial aggregation to be defined as a cluster?
2. What is the geographic extent of a cluster?
3. How concentrated does the local economy need to be to determine a cluster?
4. How strongly do the linkages between firms have to be to determine a cluster?
5. What range of associated industries can be included in a cluster?

[255] Porter (2006), p.204
[256] See Martin et al. (2003), p.10

Nevertheless, academic consensus exists on the following these core elements:

The geographical co-location of firms provides the ability to exchange codified (technical) knowledge as well as tacit knowledge (practical experience) among firms. Hence, this possibility and increased likelihood of such knowledge spillovers is the differential and crucial factor for a higher level of innovative activity.[257] Additionally, employees moving from one firm to another local firm for a better job opportunity enhances these knowledge spillovers even further.[258]

5.3 Developing a practical cluster identification approach: Exploring geographic cluster boundaries in conjunction with a Python algorithm

In consideration of the available data, each headquarter address has been converted into latitudes and longitudes with virtual basic for applications (VBA) in Microsoft Excel.

Considering the raised question of the geographical boundaries of clusters[259], it is important to acknowledge that the geographic extent of knowledge spillovers is not measurable on a common level. Because knowledge is incorporated in employees,[260] the daily commute distance of German employees can serve as a substitute indicator for the geographic extent of knowledge spillovers. However, it can be argued that more specialised employees are commuting higher distances.

In the next step, a Python algorithm has been programmed to assist with the cluster identification.[261] To account for varying commuting distances, the python algorithm identified cluster boundaries in accordance with the set radii of 5km, 15km and 25km. These radii serve to determine potential cluster boundaries. This method is inspired by Sforzi and Istat, who applied a similar approach to identifying Italian industrial districts by using the daily commuting distance to determine their radius.[262]

[257] See Sforzi (2002), p.445; Bittencourt (2019), p.29-30
[258] See Schiele (2008), p.31
[259] See Martin et al. (2003), p.10
[260] See Sforzi (2002), p.445
[261] The exact code can be found in the annexures on page A2 and the workbook can be found via this link
[262] Described by Fabiani et al. (1998), p.459-460 in Müller et al. (1999)

The Python algorithm makes sure to avoid duplicate records by performing a unique operation on the table by the company RIC.[263] Afterwards, the script loops through the firms twice, the first loop selects one firm and loops again through all the firms but the selected one to calculate the distance between all of them and the current selected one.

This distance is calculated based on the latitude and longitude of each row using the haversine distance formula. The haversine formula is an equation used in various fields such as navigation. The equation calculates the distance between two points on a sphere based on their respective longitudes and latitudes. It also eliminates the factor that the earth is slightly elliptical and accounts for a certain degree of curvature.[264] The python implementation of the haversine formula is displayed in the following code.

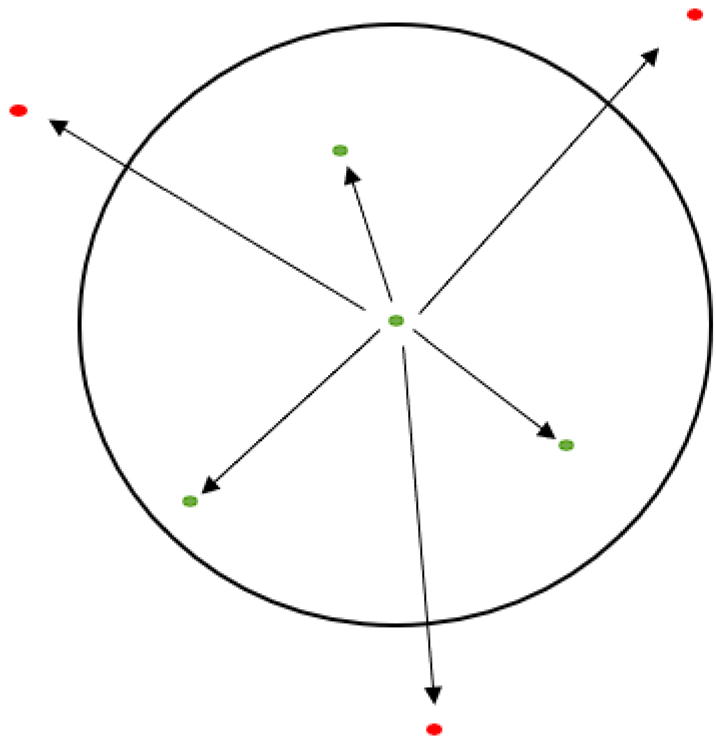
```
# Haversine function to approximate the distance between two locations
from numpy import cos, sin, arcsin, sqrt
from math import radians

def haversine(lon1,lat1, lon2,lat2):
    lon1, lat1, lon2, lat2 = map(radians, [lon1, lat1, lon2, lat2])
    dlon = lon2 - lon1
    dlat = lat2 - lat1
    a = sin(dlat/2)**2 + cos(lat1) * cos(lat2) * sin(dlon/2)**2
    c = 2 * arcsin(sqrt(a))
    km = 6367 * c
    return km
```

Moreover, three radii thresholds (5km, 15km, 25km) have been defined within the script. The script examines each individual firm location and counts the other firms within the three given radii. A visual example of the code's function is seen below.

[263] RIC refers to the Reuters Instrument Code – a given unique identifier of the Reuters database
[264] Dauni et al. (2019). p.3

Figure 5: Visual representation of the Python Code



In this visual example, the central firm has three competitors (green) within the given radius and three firms (red) outside the radius. Hence, the script only counts the three nearby firms.

The output of the script is a table where the RIC of the company is used as a firm's key identifier, and the count of the nearby firms is the value. The outcome then is transformed into a new excel data sheet.

```python
import pandas as pd
import numpy as np

for firm in firms:
    # Get lat/lng of current firm
    Ibase = df_firmdata['Identifier'] == firm
    baselat = df_firmdata.loc[Ibase, 'lat'].astype(float)
    baselng = df_firmdata.loc[Ibase, 'lng'].astype(float)
    # Loop through all other firms
    FirmsNearbyCount = 0 ## counts how many firms are within distance
    FirmsNearbyFiveKm = 0
    FirmsNearbyTenKm = 0
    FirmsNearbyFiveteenKm = 0
    FirmsNearbyTwentyKm = 0
    FirmsNearbyTwentyfiveKm = 0
    FirmsNearbyFiftyKm = 0

    for otherfirm in firms:
        if firm != otherfirm:
            Iother = df_firmdata['Identifier'] == otherfirm
            comparelat = df_firmdata.loc[Iother, 'lat'].astype(float)
            comparelng = df_firmdata.loc[Iother, 'lng'].astype(float)
            distance = haversine(baselat, baselng, comparelat, comparelng)
            if(distance) <= 1:
                FirmsNearbyCount = FirmsNearbyCount + 1
            if(distance) <= 5:
                FirmsNearbyFiveKm = FirmsNearbyFiveKm + 1
            if(distance) <= 10:
                FirmsNearbyTenKm = FirmsNearbyTenKm + 1
            if(distance) <= 15:
                FirmsNearbyFiveteenKm = FirmsNearbyFiveteenKm + 1
            if(distance) <= 20:
                FirmsNearbyTwentyKm = FirmsNearbyTwentyKm + 1
            if(distance) <= 25:
                FirmsNearbyTwentyfiveKm = FirmsNearbyTwentyfiveKm + 1
            if(distance) <= 50:
                FirmsNearbyFiftyKm = FirmsNearbyFiftyKm + 1

    df_firmdata.loc[Ibase, "FirmsNearbyOneKm"] =  FirmsNearbyCount
    df_firmdata.loc[Ibase, "FirmsNearbyFiveKm"] =  FirmsNearbyFiveKm
    df_firmdata.loc[Ibase, "FirmsNearbyTenKm"] =  FirmsNearbyTenKm
    df_firmdata.loc[Ibase, "FirmsNearbyFiveteenKm"] =  FirmsNearbyFiveteenKm
    df_firmdata.loc[Ibase, "FirmsNearbyTwentyKm"] =  FirmsNearbyTwentyKm
    df_firmdata.loc[Ibase, "FirmsNearbyTwentyfiveKm"] =  FirmsNearbyTwentyfiveKm
    df_firmdata.loc[Ibase, "FirmsNearbyFiftyKm"] =  FirmsNearbyFiftyKm
```

```python
## Export to excel

df_firmdata.to_excel('Output/Medical Equipment, Supplies & Distribution.xlsx', index = None)
```

5.4 Development of a new process for empirical cluster analysis

The core objective of this empirical research is to identify a potential positive spatial agglomeration effect on the financial performance of companies within the same industry. However, the available data was rather fragmented, especially considering a longer time horizon. Thus, the data set has been limited to three time periods for each of the four financial KPIs, and the following conditions on the dependent variables have been imposed.

1. Calculate the 3-year average for each radius given 50% of the data (minimum data points for 2 individual years) is available.
2. Calculate the 5-year average for each radius given 50% of the data (minimum data points for 3 individual years) is available.
3. Calculate the 10-year average for each radius given 50% of the data (minimum data points for 5 individual years) is available.

The 50% boundary is perceived as a suitable minimum condition for the calculation of averages and thus has been imposed on the dependent variables.

Concerning the independent variables, the greatly varying industry sizes referring to the number of firms included within each industry imposed a challenge for the empirical analysis.

Referring to the undefined cluster boundaries within academic literature, an alternative approach had to be developed.

The above-outlined Python script calculated the number of firms for each respective industry firm. The ratio between the number of firms in the respective radius and the maximum number of firms in the radius in the corresponding industry was calculated for each of the three radii. This approach partly accounts for Martin et al.'s raised question regarding the level of industrial aggregation and concentration of local economic activity required to determine a cluster.[265] Hence, this level of analysis does not aim to answer whether a firm is positioned in a local cluster or not. The objective is to account for the level of geographic agglomeration of firms to provide a more holistic overview of the financial implications of spatial firm concentration. The quartiles were calculated as follows.

[265] See Martin et al. (2003), p.10

Table 6: Definition of the focus groups for the empirical analysis

Group 1 – high concentration	≥ 75%
Group 2 – medium to high concentration	≥ 50% < 75%
Group 3 – medium to low concentration	≥ 25% < 50%
Group 4 – low concentration	< 25%

Due to this approach, the original quantitative data of the independent variables have been transformed to an ordinal scale by calculating the respective quartiles.

Considering the proper implementation of the empirical analysis, a normal distribution of the available data cannot be assumed. Additionally, the data is measured on different scale levels. Thus, the statistical model to examine the outlined hypotheses requires a non-parametric test. In these procedures, the actual measurement values themselves are not processed but rather their rank position (quartiles) in the overall sample. For this reason, they are very robust against potential outliers and allow for valid conclusions based on the achieved results, even with smaller sample sizes.[266]

Kruskal and Wallis developed a non-parametric analysis of variance (ANOVA) to determine differences between three or more independent groups with non-normally distributed data. The main advantage is that the Kruskal-Wallis test is based on ranks (in this case, quartiles) in contrast to raw data values, enhancing its robustness against violations of normality and homogeneity of variance assumptions. The test involves ranking the data from all groups combined and then calculating the sum of ranks for each group. The test statistic, which follows a chi-squared distribution, is computed from the sum of ranks and the sample sizes of the groups. The null hypothesis of the Kruskal-Wallis test expresses that there are no significant differences among the quartiles. In contrast, the alternative hypothesis implies that at least one quartile differs significantly from the others. Thus, the test only shows information if there are significant differences among groups in place, but does not provide which particular group is different in comparison to the others, which is considered the main

[266] See Nellen (2004), p.134; McFarland et al. (2016), p.178

disadvantage of the Kruskal-Wallis test. [267] A direct comparison of advantages and disadvantages of this statistical method is displayed in table 7.

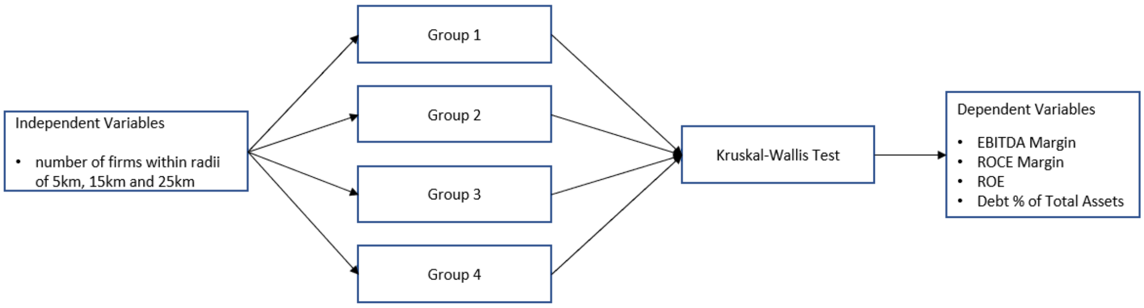
Table 7: Advantages and disadvantages of Kruskal-Wallis[268]

Advantages	**Disadvantages**
Non-parametric nature: Data does not follow a specific contribution, thus making it useful when dealing with unknown distribution or non-normally distributed data sets	Lack of post hoc tests: Determines only if there are differences among groups but not which specific groups differ from each other
Applicability: Can be used for comparison of three or more groups in comparison to parametric tests like the t-test which are designed for comparison of two groups	Ordinal data assumption: Assumes that the differences between ordinal categories are equal across groups. If this is violated, the test results may be less reliable
Robustness: Robust against outliers and does not require homogeneity of variances across groups	Reduced power: Less powerful than parametric tests (e.g. ANOVA) if the assumptions of the parametric tests are met.

A visual representation of the empirical analysis is displayed in figure 6.

[267] See Kruskal & Wallis (1952); Nellen (2004), p.135-136; Field (2017), p.236
[268] See Nellen (2004), p.134-136; McFarland et al. (2016), p.178-181

Figure 6: Conceptual model of empirical analysis



5.5 Limitations of the empirical analysis

The outlined research approach has limitations that need to be pointed out.

1. This research has been limited geographically, referring to the focus being purely on Germany.
2. The external database of Thomson Reuters assigned the allocation of firms towards their respective industries.
3. The empirical data was retrieved from an external financial database creating a dependency on secondary data.
4. The minimum number of 50 employees neglects smaller corporations, especially Startups, which are most likely to be innovative.
5. The data was limited to headquarters only. Hence subsidiaries were excluded from the data sample.
6. Cluster relationships and social embeddedness are neglected in this empirical research.

The social embeddedness and relationships between cluster firms are stressed throughout cluster theory but neglected in this research approach. Thus, further empirical research could complement the existing data set to account for cluster relationships. Potential cluster relationships indicators could be

- Cluster actors (for example, supervisory boards in several companies)
- Investors

- Joint Ventures & Strategic Alliances
- Universities
- Shared research facilities
- Secondary research organisations (for example, Fraunhofer Research Institutions)
- Shared patents
- Company formations

6 The empirical analysis draws an unequivocal conclusion

Overall, 110 German industries were analysed across four financial KPIs and three different time periods (3-year average, 5-year average and 10-year average). In summary, 3.758 individual Kruskal-Wallis variance analyses were conducted. The calculations show an unequivocal interpretation of the financial performance of cluster firms to their non-cluster peers.[269]

6.1 Empirical results on the impact of spatial agglomeration on financial performance KPIs

With respect to the **EBITDA margins**, 937 Kruskal-Wallis variance analyses have been calculated. Only 7.6% of the results were below the 0.05-significance threshold, meaning there are no significant differences between the quartiles in 92.4% of all cases. However, it is important to acknowledge the possibility of false positives regarding the chosen level of $\alpha = 0.05$. Nevertheless, due to the number of conducted Kruskal-Wallis tests and the small impact of a false positive, the chosen significance threshold is perceived as sufficient as a decrease would increase the likelihood of false negatives in return. Hence, the following analyses will all be conducted with the 0.05 significance threshold.

Concluding, hypothesis 1a has to be rejected.

Table 8: Statistical results of analysis of the EBITDA margins

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Values < 0,05	11 (10,7%)	10 (9,5%)	9 (8,7%)	6 (5,8%)	6 (5,7%)	5 (4,8%)	7 (6,8%)	7 (6,7%)	10 (9,5%)
Values ≥ 0,05	92 (89,3%)	95 (90,5%)	94 (91,3%)	97 (94,2%)	99 (94,3%)	100 (95,2%)	96 (93,2%)	98 (93,3%)	95 (90,5%)
Total industries included	103	105	103	103	105	105	103	105	105

[269] An overview of the results for all industries and KPIs can be found on page A10 or via this link.

Referring to Table 5, the total industries included shows the number of Kruskal-Wallis tests performed for each specific category. For example, in the 5km and 3-year average analysis, 103 Kruskal-Wallis tests were conducted (1 test for each respective industry). 11 out of 103 tests provided a significant difference among the quartiles which equals to 10,7% of all conducted Kruskal-Wallis tests in this category. 89,3% or 92 industries did not show any significant differences among groups. The table does not provide insight which industries show significant differences among their respective groups. This presentation serves as a summary of results and indicates the low level of significant results produced by the analysis. Furthermore, this interpretation is given for all the following tables with the respective structure of Table 8.

Concerning the **debt % of total assets**, 939 Kruskal-Wallis variance analyses have been calculated. Only 3.9% of the results were below the 0.05-significance threshold, meaning there are no significant differences between the quartiles in 92.4% of all cases. Hence, hypothesis 1-b has to be rejected.

Table 9: Statistical results of analysis of the total debt % of total assets

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Values < 0.05	3 (2.9%)	8 (7.5%)	6 (5.7%)	3 (3.0%)	5 (4.7%)	4 (3.8%)	2 (2.0%)	1 (0.9%)	5 (4.7%)
Values ≥ 0.05	99 (97.1%)	98 (92.5%)	99 (94.3%)	97 (97.0%)	101 (95.3%)	102 (96.2%)	99 (98.0%)	105 (99.1%)	102 (95.3%)
Total industries included	102	106	105	100	106	106	101	106	107

With respect to the **ROE margins**, 933 Kruskal-Wallis variance analyses have been calculated. Only 7.3% of the results were below the 0.05 significance threshold. Thus, the model was not able to detect any significant differences between the quartiles in 92.7% of all cases. In conclusion, hypothesis 1-c has to be rejected.

Table 10: Statistical results of analysis of the ROE margin

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Values < 0.05	8 (7.8%)	9 (8.7%)	13 (12.4%)	6 (5.8%)	6 (5.8%)	8 (7.6%)	6 (5.9%)	8 (7.7%)	4 (3.8%)
Values ≥ 0.05	95 (92.2%)	94 (91.3%)	92 (87.6%)	97 (94.2%)	98 (94.2%)	97 (92.4%)	95 (94.1%)	96 (92.3%)	100 (96.2%)
Total industries included	103	105	105	103	104	105	101	104	104

For the **ROCE margins**, 940 Kruskal-Wallis variance analyses have been calculated. Only 8.3% of the results were below the 0.05 significance threshold. Thus, the model was not able to detect any significant differences between the quartiles in 91.7% of all cases. In conclusion, hypothesis 1-d has to be rejected.

Table 11: Statistical results of analysis of the ROCE margin

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Values < 0.05	9 (8.7%)	9 (8.6%)	11 (10.5%)	7 (6.7%)	9 (8.6%)	7 (6.7%)	10 (9.8%)	5 (4.8%)	11 (10.5%)
Values ≥ 0.05	95 (91.3%)	96 (91.4%)	94 (89.5%)	97 (93.3%)	96 (91.4%)	98 (93.3%)	92 (90.2%)	100 (95.2%)	94 (89.5%)
Total industries included	104	105	105	104	105	105	102	105	105

6.2 Exploring industry-specific financial performance: An in-depth analysis of individual industries

Following the summary of results, a more in-depth analysis had to be applied. The significance thresholds were plotted in a large sheet and thus, patterns of significant results in specific industries were able to be identified. This process was conducted for every financial KPI.

For the **EBITDA margin**, the results of two industries stand out. *Biotechnology & Medical Research* and *Electric Utilities* provide an uncommon clustering of significant results.

Table 12: Significant empirical results on two industries with respect to their EBITDA margins

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Biotechnology & Medical Research	0.030	0.006	0.009	0.015	0.006	0.012	0.252	0.044	0.075
Electric Utilities	0.003	0.023	0.149	0.063	0.025	0.070	0.140	0.030	0.006

Table 12 shows the significance levels of the Kruskal-Wallis analyses. For example, the analysis of the 3-year average and 5km radius shows a value of 0.03 meaning there are significant differences between the 4 quartiles of these incorporated firms.

An in-depth analysis of the respective quartiles provides the following results displayed in table 10. The in-depth analysis considers the original quantitative data. In order to account for outliers, the median EBITDA margin will serve as a comparison between the quartiles.

Table 13: In-depth analysis of Biotechnology & Meddical Research

Biotechnology & Medical Research	3-Year Median			5-Year Median			10-Year Median		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Group 1 – high concentration	-141.0%	-91.5%	-53.7%	-178.2%	-80.4%	-80.4%	-159.2%	-103.0%	-103.0%
Group 2 – medium to high concentration	-91.5%	-83.8%	6.8%	n.a.	-221.0%	7.0%	n.a.	-228.2%	5.5%
Group 3 – medium to low concentration	6.9%	6.9%	5.3%	7.3%	7.3%	5.6%	7.2%	8.5%	5.4%
Group 4 – low concentration	9.1%	11.4%	14.7%	9.2%	10.7%	12.6%	10.2%	12.2%	14.2%

The dataset of the *Biotechnology & Medical Research* industry consists of 177 companies. The *Biotechnology & Medical Research* firms are expected to rely significantly on innovation for their respective business performance and thus depend on the creation and diffusion of knowledge. Therefore, it is rather contradictory that group 1, with the highest number of nearby firms, performs the worst in comparison to all groups. Group 4 is the best-performing group independent of the time period or the radius. Within the Biotechnology & Medical Research industry, a lower number of industry competitors appears to positively impact the financial performance in terms of the EBITDA margin.

Prevezer conducted a study on American biotechnology clusters in the 1990s. She argued that the cost of clusters within the biotechnology industry is twofold. Considering the supply side, competition increases input factors such as labour and land, providing the example of Silicon Valley, where the local real estate and labour market prevents new companies from settling down within that area. In consideration of the demand side, Prevezer argues that costs of competition are likely to occur, giving the example of competition on the same product leading to a reduction in profits. Additionally, a race for a particular product and its monopoly increases the likelihood of any firm winning the race due to limited access to required scarce resources and, thus, local congestion.[270] Furthermore, research revealed that biotechnology incumbents are "effective in absorbing spillovers in their proximity within their own sector."[271] It is also argued that this particular industry greatly depends on its local environment, referring to research, financing and similar infrastructural resources, which new entrants are less likely to be able to exploit fully.[272]

Hence, a likely reason for the enhanced profitability of Group 4 could be the industry's dependency on highly skilled personnel leading to hyper-competition for skilled workers and, thus, a significant increase in personnel expenses.[273] Additionally, an access monopoly to local infrastructural resources is perceived as beneficial to the local firm's profitability.

The second noticeable industry *Electric Utilities* consists of 384 companies. An in-depth analysis provides rather ambiguous findings shown in table 14.

[270] See Prevezer (1997), p.259
[271] See Swann et al. (1996), p.1155
[272] See Swann et al. (1996), p.1155
[273] See Fabiani et al. (1998), p.463 in Müller et al. (1999); Schiele et al. (2012), p.16

Table 14: In-depth analysis of Electric Utilities

Electric Utilities	3-Year Median			5-Year Median			10-Year Median		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Group 1 – high concentration	0.2%	2.3%	15.6%	7.1%	4.9%	14.6%	9.9%	4.9%	16.0%
Group 2 – medium to high concentration	4.5%	13.4%	11.9%	5.7%	14.3%	11.6%	5.4%	14.2%	10.8%
Group 3 – medium to low concentration	8.4%	8.4%	11.3%	8.8%	8.9%	11.3%	8.5%	11.0%	12.9%
Group 4 – low concentration	12.7%	12.8%	12.7%	13.4%	13.4%	13.4%	13.8%	14.1%	14.1%

Considering the smaller radius of 5km, group 4, with the lowest number of industry competitors, performs the best independent of the time period. A slightly wider radius of 15km leads to a slightly different result. Groups 2 and 4 are the best-performing groups within this radius, independent of the time period. Extending the radius even further to 25km, group 1, with the highest number of industry competitors, provides the highest median EBITDA margin. It appears that the extension from 15km to 25km leads to an inclusion of better-performing firms from group 2 into group 1. Hence, the cluster boundaries and potential positive externalities for this particular industry appear to be present in a wider radius.

The *Auto & Truck Manufacturers* industry has produced five significant results with respect to the **total debt % of total assets**. Hence an in-depth analysis of the group performances regarding the different time periods and spatial ranges has been conducted.

Table 15: In-depth analysis of Auto & Truck Manufacturers on their debt % of total assets

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Auto & Truck Manufacturers Variances	0.425	0.135	0.020	0.242	0.031	0.002	0.652	0.021	0.004
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Group 1 – high concentration	18.6%	2.6%	2.6%	23.1%	2.0%	2.0%	28.8%	2.9%	2.9%
Group 2 – medium to high concentration	18.4%	27.4%	39.9%	11.4%	24.1%	35.7%	23.6%	18.0%	31.1%
Group 3 – medium to low concentration	36.8%	38.7%	19.5%	30.7%	34.8%	17.6%	29.3%	31.2%	24.8%
Group 4 – low concentration	37.5%	37.3%	38.8%	35.7%	39.4%	41.2%	31.1%	32.9%	40.4%

The data sample of the Auto & Truck Manufacturers industry consists of 239 individual firms. In table 15, it can be observed that with the exception of the 10-year average within a 5km radius, the most clustered companies have the lowest debt % of total assets in their respective balance sheets. The reason for this phenomenon remains unidentified. However, one potential reason might be the German banking structure. Germany developed a unique banking system with a large number of regional banks that are geographically constrained to conduct business only within their respective administrative districts.274 Nevertheless, Germany is considered the prototype of a bank-based financial system, meaning that the majority of corporate lending is conducted via banks.275 This unique system might limit the leverage ratio of the Auto & Truck Manufacturers as the banks might be rather hesitant to overinvest in one particular industry due to their respective risk structures.

The *Banking* and the *Healthcare Facilities & Services* industry produced an unusually high number of significant results for **ROE margins**, as shown in Table 16.

Table 16: Significant empirical results on two industries with respect to their ROE margins

	3-Year Average			5-Year Average			10-Year Average		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Banks	0.007	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Healthcare Facilities & Services	0.435	0.086	0.039	0.364	0.015	0.004	0.004	0.001	0.001

[274] See Behr et al. (2016), p.542 in Beck et al. (2016)
[275] See Behr et al. (2016), p.544 in Beck et al. (2016)

The in-depth analysis for *Banks* provided the following results presented in Table 17.

Table 17: In-depth analysis of Banks on their ROE margin

Banks	3-Year Median			5-Year Median			10-Year Median		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Group 1 – high concentration	-2.3%	1.8%	1.8%	-1.2%	-0.8%	-0.8%	1.7%	1.8%	1.8%
Group 2 – medium to high concentration	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Group 3 – medium to low concentration	7.0%	6.0%	5.6%	9.7%	5.6%	5.6%	10.8%	5.1%	5.1%
Group 4 – low concentration	-1.3%	-1.6%	-1.6%	-1.6%	-1.8%	-1.8%	-1.9%	-2.0%	-2.0%

The analysed data sample consists of 355 individual banks. Group 3 always performed the best out of all quartiles, independent of the radius or the observed time period. Hence, a small number of competitors in a geographically concentrated area appear to positively impact the ROE margin for *Banks*. A rationale for this phenomenon might be that *Banks* require some local competition to keep their processes and risk management current. Still, a more intense competitive environment leads to smaller margins resulting in lower profitability for equity holders. However, a more in-depth analysis of the respective banks and their main area of business (for example, lending, investment banking, and private banking) could provide a more comprehensive explanation.

The in-depth analysis of the *Healthcare Facilities & Services* industry is shown in Table 18.

Table 18: In-depth analysis of Healthcare Facilities & Services on their ROE margin

Healthcare Facilities & Services	3-Year Median			5-Year Median			10-Year Median		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
Group 1 – high concentration	4.7%	5.7%	4.3%	2.8%	12.9%	6.4%	10.1%	15.7%	7.4%
Group 2 – medium to high concentration	5.5%	9.2%	6.1%	5.6%	9.4%	7.9%	8.1%	10.1%	7.5%
Group 3 – medium to low concentration	3.3%	4.1%	3.3%	3.2%	4.2%	3.7%	2.2%	3.9%	2.3%
Group 4 – low concentration	3.6%	3.3%	3.0%	4.3%	3.6%	3.3%	3.7%	3.4%	3.1%

The empirical analysis of *Healthcare Facilities & Services* was conducted on 1.385 firms. Groups 1 and 2 perform better independent of the radius and time period, with the exception of the 5-year median for the 5km radius in Group 1. Nevertheless, a higher competitive clustering of *Healthcare Facilities & Services* firms generates a significantly higher ROE margin in comparison to low to none competition. One potential reason could be enhanced access to patients resulting in higher revenues. Additionally, a very competitive environment could have led to highly specialised health facilities. A higher degree of specialisation provides opportunities for favourable pricing leading to an increased ROE margin. Concluding, local positive synergy effects due to clustering are apparent.

Interestingly, the *Healthcare Facilities & Services* industry is the only industry that has produced noticeable results for both the ROE and ROCE margin.

Table 19: In-depth analysis of Healthcare Facilities & Services on their ROCE margins

Healthcare Facilities & Services	3-Year Median			5-Year Median			10-Year Median		
	5km	15km	25km	5km	15km	25km	5km	15km	25km
	0.009	0.040	0.121	0.085	0.043	0.159	0.004	0.001	0.004
Group 1 – high concentration	3.7%	7.4%	3.0%	2.9%	10.3%	2.9%	5.2%	15.2%	3.9%
Group 2 – medium to high concentration	4.0%	3.4%	3.4%	3.1%	3.7%	3.5%	5.2%	4.7%	3.4%
Group 3 – medium to low concentration	2.2%	2.2%	3.2%	2.0%	2.2%	3.1%	1.4%	1.9%	2.3%
Group 4 – low concentration	2.0%	2.0%	1.7%	2.3%	2.3%	2.1%	2.3%	2.1%	1.8%

Equally to the ROE margin, groups 1 and 2 show an increased financial performance for the ROCE margin independent of the radius or time period in the *Healthcare Facilities & Services* industry.

An in-depth analysis of the respective companies contributing to these significant results for both margins could lead to a more comprehensive understanding. One potential reason for this phenomenon could be an improved provision of healthcare services towards patients in a highly concentrated region. A high concentration of healthcare facilities and services is likely to foster specialisation, enabling market healthcare services at a price premium compared to non-cluster peers. This industry is particularly interesting due to its implications for the general German society. Considering the fundamental need for an affordable and high-quality healthcare system, a rather low profitability of *Healthcare Facilities & Services* could be favoured from a societal perspective.

6.3 Exploring industry-specific financial performance: A summary of empirical results

The developed empirical model based on a variance analysis by Kruskal-Wallis has led to rather disappointing results. Only 254 out of 3.748 variance analyses resulted in statistically significant results. Consequently, the hypotheses 1a-d have been rejected.

Nevertheless, every financial KPI provided 1 or 2 industries with a noticeable amount of significant results. The in-depth analyses on the industry level have not contributed to a comprehensive understanding referring to the differences in the financial performance of the quartiles.

With respect to profitability financial KPIs, the EBITDA margin has provided mixed results, with *Biotechnology & Medical Research* benefitting from a low degree of spatial competition. On the contrary, the Electric Utilities industry has shown that a bigger radius of 25km has led to a significant increase in the EBITDA performance in a highly competitive spatial environment.

The ROE and ROCE margin were both positively impacted by a high degree of spatial firm concentration in the *Healthcare Facilities & Services* industry. In contrast, *Banks* have shown a significantly enhanced ROE margin with a low degree of competition. The *Construction & Engineering* industry has shown significantly increased ROCE margins for firms in the highly competitive spatial environment and in a spatial environment with little to no competition at all.

The Debt % of Total Asset ratio has provided higher leverage for some to little spatial competition in the *Auto & Truck Manufacturers* industry.

A deep dive into the significant industries and their financial KPIs could provide further insights into positive financial contributors such as:

- Regional differences within the respective industry
- Variations in business focus
- Variations in social embeddedness

In summary, the in-depth analyses have led to contrary results, thus general statements on the financial performance of cluster firms cannot be derived.

7 Reevaluating the impact of cluster memberships: Insights on financial performance, knowledge dynamics and social relations

In conclusion, this study has provided valuable insights into the financial performance of cluster firms in comparison to their non-cluster peers.

The composed empirical model partly accounts for raised questions concerning the geographic extent of clusters, the required level of industrial aggregation and the concentration of local economic activity. [276]

The conducted empirical analysis does not provide sufficient evidence for cluster firms' enhanced financial performance compared to their non-cluster peers. Three reasons for this outcome are highly likely.

First, spatial agglomeration of firms appears not to be a standalone characteristic for the enhanced financial performance of cluster firms in Germany. Reconsidering the academic literature and cluster definitions in a close spatial context, firms' social embeddedness and local network are stressed significantly, especially within the literature rooted in the Marshallian theories.[277] Deriving from this model, it can be argued that spatial agglomeration does not necessarily lead to local network embeddedness. In fact, some authors even argue that the term cluster can only be used in case of proven local social structures.[278] Hence, the concept of an "*Innovative Milieu"* which strongly advocates for the establishment of socioeconomic relations as the main driver for local innovation processes needs to be emphasised and is crucial for local performance enhancements of firms.[279]

Secondly, the concept of "*Absorptive Capacity*" is neglected in this research and context. Absorptive capacity refers to the individual and organisational capability to acknowledge the value of external information and comprehend and incorporate it into commercial activities.[280] It is important to acknowledge that in the organisational context, a firm's

[276] See Martin et al. (2003), p.10
[277] See Schiele et al. (2012), p.685; Jonas (2014), p.16; Moodysson et al. (2014), p.135
[278] See Oosterhaven et al. (2001), p.811; Visser (2009), p.179
[279] See Camagni (1995), p.319
[280] See Cohen et al. (1990), p.128

absorptive capacity is not solely dependent on its employees and their interaction with the external environment. The organisational learning process, including the transfer of knowledge across multiple internal subunits, significantly defines a firm’s absorptive capacity. Hence, the internal and external communication structure might become a bottleneck to a firm’s distribution of knowledge and, thus, its absorptive capacity.[281] The organisational absorptive capacity partly transfers back to the social embeddedness of clusters but differs by accounting for potential internal obstacles of knowledge diffusion, thus hampering innovative activities.

Third, cluster membership might improve the innovative performance of local firms. However, the innovations are not necessarily utilised by their innovators, thus not leading to enhanced profitability. However, research has shown that the impact on a user’s productivity is far bigger than the producer’s productivity. Hence, the innovator's profitability might not be a sufficient criterion to determine the value of the innovation.[282]

Reconsidering the similar research conducted by Fabiani et al. on the performance of Italian districts, two main differences have to be acknowledged. First, structural differences between Italy and Germany might be in place. Fabiani et al. argued that Italy’s industry structure of many small firms makes it more similar to emerging economies than to the G7 countries.[283] Secondly, Fabiani et al. conducted their research in the early to mid-1990s. The data set analysed in this research is from 2011 – 2021. Modern communication technologies have significantly changed the process of information sharing which could dilute this particular cluster benefit.[284] However, the distinction between information and knowledge and, thus, the role of tacit knowledge in the innovation process remains untouched.

[281] See Cohen et al. (1990), p.131-132
[282] See Geroski et al. (1993), p.208
[283] See Fabiani et al. (1998), p.457 in Müller et al. (1999)
[284] See Kukalis (2010), p.476

Table 20: Comparison of empirical analysis approaches

Author	**Fabiani et al**	**Fuhrken**
Country of analysis	Italy	Germany
Industries included	13 manufacturing industries (e.g. textiles, machinery, electronics, wood)[285]	126 industries included
Cluster structure	Pre-determined local labour systems (LLS) and postal codes	Radii of 5km, 15km and 25km
Number of firms	10.900	28.874
Time horizon	Mainly 1995 Some variables 1982-1995	2011 – 2021 (10 years)
Financial KPIs included	ROI, ROE, Share of gross operating profits on value added	ROE, ROCE, EBITDA Margin, Total Debt % of Total Assets

Overall, the research approaches had the same objective. Identification of a clustering effect on financial performance on the firm level. Fabiani et al's research was limited to 13 industries of manufacturing firms in comparison to the entire economic landscape of Germany. Additionally, the sample sizes referring to number of firms and time horizon differed significantly. The main difference is the approach regarding the identification process of clusters. Fabiani et al. depended on the pre-determined LLS from the Italian government. The division process and borders of LLS are unknown. The conducted research for Germany used an independent approach by measuring the radii and thus determined the density of industry firms for each respective firm.

According to the conducted analysis, cluster membership does not enhance firms' financial performance in Germany. Individual exceptions on some financial KPIs occur but are rather limited and cannot be generalised. Hence, local social relationships are likely to occupy a significant role in the process of knowledge sharing and, thus, innovation.

[285] A detailed view of the included industries can be seen in Fabiani et al. (1998), p.467

Due to the importance of local social relationships for the theoretical cluster benefits, local policy makers should foster local cooperation of industry firms. Joint research centers could lead to a thriving transfer and accumulation of knowledge and thus drive innovation. However, such projects might not necessarily lead to an increased financial performance on the firm level. Nevertheless, local social embeddedness and gaining value from these local relations will strengthen a firm's commitment to its geographical roots and thus increase the likelihood of regional long-term employment and economic prosperity which can be considered a core objective of local policy makers. However, the effectiveness of policies needs to be continuously monitored to ensure their validity.

The conducted research also provides some other practical implications. For example, financial analysists and investors can disregard a potential clustering effect on firm performance in a firm's valuation analysis. Furthermore, entrepreneurs do not necessarily need to position their venture in an existing cluster to gain financial benefits. Their strategic decision making for a firm's location should rather be triggered by accessibility to required assets for example human resources. Thus, entrepreneurs and managers need to continuously evaluate a firm's geographical location. In case the intensity of local competitive forces decreases prices and more value in terms of financial performance leading to long-term survival of the firm can be gained from repositioning, managers are required to consider this option. Furthermore, consolidation might be a potential process to enhance a firm's performance in the long-term and drive the performance of the local ecosystem. Lastly, venturing into other geographical locations with subsidiaries could lead to a greater accumulation of knowledge. However, managers need to ensure flow of information and transfer of knowledge between multiple corporate locations to strengthen such a competitive advantage.

8 Expanding the scope: Limitations and future research

Cluster theory remains a widely discussed topic within the scientific community. Unfortunately, this piece of empirical research did not support the underlying assumptions of spatial agglomeration economies.

Reconsidering chapter 5.5, adding additional data to the conducted empirical research might provide empirical evidence on the impact of additional factors besides spatial agglomeration of firms. For example, data on local joint ventures & strategic alliances would provide sufficient information on local embeddedness and could serve as a proxy for knowledge sharing and knowledge transfers. The same argument can be made for cluster actors such as supervisory board members or investors (however, it can be argued that the knowledge transfer might not be as strong as in direct collaborations via joint ventures). The role of local socioeconomic relations appears to be of significant value, hence including data on local social embeddedness and communication might facilitate the outlined research process significantly.

For further research, the radius of analysis could be extended over the 25km threshold to potentially identify a positive impact on financial performance with a larger radius (for example 50km). However, across all industries a positive relationship between number of industry firms and financial performance could not be established with minimal exceptions.

Nevertheless, these exceptions could be subject to further research. What differs in comparison to other spatial places in this particular industry? Are there specific infrastructural benefits like universities or other research facilities in place that provide state-of-the-art knowledge that fosters financial performance? Have firms formed joint ventures or strategic local alliances that lead to an improvement of financial performance? Are these exceptions even the joint ventures and multiple firms hold ownership in these companies? Did a firm split into multiple separate legal entities? Information towards these questions could serve as a proxy for cluster relationships and thus knowledge spillovers, the core element within cluster theory.

Further research on the financial implications of clusters on a firm level will be beneficial to a broad spectrum of stakeholders, for example, on the firm level founders, equity and debt investors, but also on the macro level, for example, policymakers.

9 Bibliography

1. Aghion, Philippe; Harris, Christopher; Vickers, John (1997): Competition and growth with step-by-step innovation: An example. In: *European Economic Review* 41 (3-5), S. 771–782. DOI: 10.1016/S0014-2921(97)00036-6.
2. Almeida, Rita (2007): Local Economic Structure and Growth. In: *Spatial Economic Analysis* 2 (1), S. 65–90. DOI: 10.1080/17421770701232442.
3. Antonelli, Cristiano; Crespi, Francesco; Mongeau Ospina, Christian A.; Scellato, Giuseppe (2017): Knowledge composition, Jacobs externalities and innovation performance in European regions. In: *Regional Studies* 51 (11), S. 1708–1720. DOI: 10.1080/00343404.2016.1217405.
4. Audia, Pino G.; Sorenson, Olav; Hage, Jerald (2001): Tradeoffs in the organization of production: Multiunit firms, geographic dispersion and organizational learning. In: Joel A. C. Baum und H. R. Greve (Hg.): Multiunit Organization and Multimarket Strategy, Bd. 18. Bingley: Emerald (MCB UP) (Advances in strategic management), S. 75–105.
5. Audretsch, David B.; Feldman, Maryann P. (1996): R&D Spillovers and the Geography of Innovation and Production. In: *The American Economic Review* 86 (3), S. 630–640.
6. Baptista, Rui (2000): Do innovations diffuse faster within geographical clusters? In: *International Journal of Industrial Organization* 18 (3), S. 515–535. DOI: 10.1016/S0167-7187(99)00045-4.
7. Baptista, Rui (2003): Productivity and the Density of Local Clusters. In: Johannes Bröcker, Dirk Dohse und Rüdiger Soltwedel (Hg.): Innovation Clusters and Interregional Competition. Berlin, Heidelberg: Springer Berlin Heidelberg (Advances in Spatial Science), S. 163–181.
8. Baptista, Rui; Swann, Peter (1998): Do firms in clusters innovate more? In: *Research Policy* 27 (5), S. 525–540. DOI: 10.1016/S0048-7333(98)00065-1.
9. Barney, Jay; Wright, Mike; Ketchen, David J. (2001): The resource-based view of the firm: Ten years after 1991. In: *Journal of Management* 27 (6), S. 625–641. DOI: 10.1177/014920630102700601.
10. Bathelt, Harald; Glückler, Johannes (2003): Wirtschaftsgeographie. Ökonomische Beziehungen in räumlicher Perspektive; 16 Tabellen. 2., korr. Aufl. Stuttgart (Hohenheim): Ulmer (UTB, 8217).
11. Bathelt, Harald; Malmberg, Anders; Maskell, Peter (2004): Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. In: *Progress in Human Geography* 28 (1), S. 31–56. DOI: 10.1191/0309132504ph469oa.
12. Batten, David; Casti, John; Thord, Roland (Hg.) (1995): Networks in Action. Berlin, Heidelberg: Springer Berlin Heidelberg.
13. Batten, David F.; Andersson, Åke E.; Kobayashi, Kiyoshi; Yoshikawa, Kazuhiro (Hg.) (1993): The Cosmo-Creative Society. Berlin, Heidelberg: Springer Berlin Heidelberg (Advances in Spatial and Network Economics).

14. Baum, Joel A. C.; Greve, H. R. (Hg.) (2001): Multiunit Organization and Multimarket Strategy. Bingley: Emerald (MCB UP) (Advances in strategic management).
15. Beaudry, Catherine; Breschi, Stefano (2003): Are firms in clusters really more innovative? In: *Economics of Innovation and New Technology* 12 (4), S. 325–342. DOI: 10.1080/10438590290020197.
16. Beaudry, Catherine; Schiffauerova, Andrea (2009): Who's right, Marshall or Jacobs? The localization versus urbanization debate. In: *Research Policy* 38 (2), S. 318–337. DOI: 10.1016/j.respol.2008.11.010.
17. Beck, Thorsten; Casu, Barbara (Hg.) (2016): The Palgrave Handbook of European Banking. London: Palgrave Macmillan UK.
18. Behr, Patrick; Schmidt, Reinhard H. (2016): The German Banking System. In: Thorsten Beck und Barbara Casu (Hg.): The Palgrave Handbook of European Banking. London: Palgrave Macmillan UK, S. 541–566.
19. Ben Abdesslem, Amel; Chiappini, Raphaël (2019): Cluster policy and firm performance: a case study of the French optic/photonic industry. In: *Regional Studies* 53 (5), S. 692–705. DOI: 10.1080/00343404.2018.1470324.
20. Bigliardi, Barbara (2013): The effect of innovation on financial performance: A research study involving SMEs. In: *Innovation* 15 (2), S. 245–255. DOI: 10.5172/impp.2013.15.2.245.
21. Bittencourt, B.A., Daniel, V.M., Zen, A.C., & Galuk, M.B. (2019): Cluster Innovation Capability: a systematic review. In: *International Journal of Innovation* 7 (1), S. 26–44.
22. Bottazzi, G.; Secchi, A.; Tamagni, F. (2008): Productivity, profitability and financial performance. In: *Industrial and Corporate Change* 17 (4), S. 711–751. DOI: 10.1093/icc/dtn027.
23. Boyce, David E.; Nijkamp, Peter; Shefer, Daniel (Hg.) (1991): Regional Science. Berlin, Heidelberg: Springer Berlin Heidelberg.
24. Braune, Eric; Mahieux, Xavier; Boncori, Anne-Laure (2016): The Performance of Independent Active SMEs in French Competitiveness Clusters. In: *Industry and Innovation* 23 (4), S. 313–330. DOI: 10.1080/13662716.2016.1145574.
25. Breschi, S.; Lissoni, F. (2001): Knowledge Spillovers and Local Innovation Systems: A Critical Survey. In: *Industrial and Corporate Change* 10 (4), S. 975–1005. DOI: 10.1093/icc/10.4.975.
26. Bröcker, Johannes; Dohse, Dirk; Soltwedel, Rüdiger (Hg.) (2003): Innovation Clusters and Interregional Competition. Berlin, Heidelberg: Springer Berlin Heidelberg (Advances in Spatial Science).
27. Camagni, R. P. (1991): Technological Change, Uncertainty and Innovation Networks: Towards a Dynamic Theory of Economic Space. In: David E. Boyce, Peter Nijkamp und Daniel Shefer (Hg.): Regional Science. Berlin, Heidelberg: Springer Berlin Heidelberg, S. 211–249.
28. Camagni, Roberto P. (1995): THE CONCEPT OF INNOVATIVE MILIEU AND ITS RELEVANCE FOR PUBLIC POLICIES IN EUROPEAN LAGGING REGIONS. In: *Papers in Regional Science* 74 (4), S. 317–340. DOI: 10.1111/j.1435-5597.1995.tb00644.x.

29. Caragliu, Andrea; Dominicis, Laura de; Groot, Henri L.F. de (2016): Both Marshall and Jacobs were Right! In: *Economic Geography* 92 (1), S. 87–111. DOI: 10.1080/00130095.2015.1094371.

30. Cernavin, Oleg; Führ, Martin; Kaltenbach, Martin; Thießen, Friedrich (2005): Cluster und Wettbewerbsfähigkeit von Regionen. Erfolgsfaktoren regionaler Wirtschaftsentwicklung. 1. Auflage. Berlin: Duncker & Humblot GmbH (Volkswirtschaftliche Schriften, 543).

31. Clark, Gordon L.; Feldman, Maryann P.; Gertler, Meric S.; Wójcik, Dariusz (2018): The New Oxford Handbook of Economic Geography: Oxford University Press (1).

32. Cohen, Wesley M.; Levinthal, Daniel A. (1990): Absorptive Capacity: A New Perspective on Learning and Innovation. In: *Administrative Science Quarterly* 35 (1), S. 128. DOI: 10.2307/2393553.

33. Combes, Pierre-Philippe (2000): Economic Structure and Local Growth: France, 1984–1993. In: *Journal of Urban Economics* 47 (3), S. 329–355. DOI: 10.1006/juec.1999.2143.

34. Combes, Pierre-Philippe; Duranton, Gilles (2006): Labour pooling, labour poaching, and spatial clustering. In: *Regional Science and Urban Economics* 36 (1), S. 1–28. DOI: 10.1016/j.regsciurbeco.2005.06.003.

35. Curado, Carla; Muñoz-Pascual, Lucía; Galende, Jesús (2018): Antecedents to innovation performance in SMEs: A mixed methods approach. In: *Journal of Business Research* 89, S. 206–215. DOI: 10.1016/j.jbusres.2017.12.056.

36. Dauni, P.; Firdaus, M.D.; Asfariani, R.; Saputra, M.I.N.; Hidayat, A.A.; Zulfikar, W.B. (2019): Implementation of Haversine formula for school location tracking. In: *J. Phys.: Conf. Ser.* 1402 (7), S. 77028. DOI: 10.1088/1742-6596/1402/7/077028

37. Dess, Gregory G.; Picken, Joseph C. (2000): Changing roles: Leadership in the 21st century. In: *Organizational Dynamics* 28 (3), S. 18–34. DOI: 10.1016/S0090-2616(00)88447-8.

38. Dosi, Giovanni (1988): Sources, Procedures, and Microeconomic Effects of Innovation. In: *Journal of Economic Literature* 26 (3), S. 1120–1171.

39. Dunning, John H. (2014): Alliance capitalism and global business. 1. publ. in 1997, 1. issued in paperb. London: Routledge (Routledge Studies in International Business and the World Economy, 7).

40. Duranton, Gilles; Puga, Diego (2004): Chapter 48 Micro-foundations of urban agglomeration economies. In: J.Vernon Henderson und J. F. Thisse (Hg.): Cities and Geography, Bd. 4: Elsevier (Handbook of Regional and Urban Economics), S. 2063–2117.

41. Fang, Li (2015): Do Clusters Encourage Innovation? A Meta-analysis. In: *Journal of Planning Literature* 30 (3), S. 239–260. DOI: 10.1177/0885412215589848.

42. Farhauer, Oliver; Kröll, Alexandra (2014): Standorttheorien. Regional- und Stadtökonomik in Theorie und Praxis. 2., durchgeseh. u. korr. Aufl. 2014. Wiesbaden: Gabler.

43. Feldman, Maryann P. (1999): The New Economics Of Innovation, Spillovers And Agglomeration: Areview Of Empirical Studies. In: *Economics of Innovation and New Technology* 8 (1-2), S. 5–25. DOI: 10.1080/10438599900000002.

44. Feldman, Maryann P.; Audretsch, David B. (1999): Innovation in cities. In: *European Economic Review* 43 (2), S. 409–429. DOI: 10.1016/S0014-2921(98)00047-6.

45. Feser, Edward J. (1998): Old and new theories of industry clusters, S. 1–27. Online verfügbar unter https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.959.2576&rep=rep1&type=pdf, zuletzt geprüft am 07.06.2022.
46. Field, Andy (2017): Discovering Statistics Using IBM SPSS Statistics. 5. Aufl. London: SAGE Publications Ltd.
47. Fischer, Manfred M.; Fröhlich, Josef (Hg.) (2001): Knowledge, Complexity and Innovation Systems. Berlin, Heidelberg: Springer Berlin Heidelberg (Advances in Spatial Science).
48. Freeman, Christopher; Soete, Luc (2000): The economics of industrial innovation. 3. edition, reprinted. Cambridge, Mass.: MIT.
49. Frenken, Koen; van Oort, Frank G.; Verburg, Thijs; Boschma, Ron A. (2005): Variety and Regional Economic Growth in the Netherlands. In: *SSRN Journal*. DOI: 10.2139/ssrn.871804.
50. Galliano, Danielle; Magrini, Marie-Benoît; Triboulet, Pierre (2015): Marshall's versus Jacobs' Externalities in Firm Innovation Performance: The Case of French Industry. In: *Regional Studies* 49 (11), S. 1840–1858. DOI: 10.1080/00343404.2014.950561.
51. Galliano, Danielle; Roux, Pascale; Soulié, Nicolas (2011): ICT Intensity of Use and the Geography of Firms. In: *Environ Plan A* 43 (1), S. 67–86. DOI: 10.1068/a43167.
52. Gellynck, Xavier; Vermeire, Bert (2009): The Contribution of Regional Networks to Innovation and Challenges for Regional Policy. In: *International Journal of Urban and Regional Research* 33 (3), S. 719–737. DOI: 10.1111/j.1468-2427.2009.00887.x.
53. Geroski, Paul; Machin, Steve; van Reenen, John (1993): The Profitability of Innovating Firms. In: *The RAND Journal of Economics* 24 (2), S. 198. DOI: 10.2307/2555757.
54. Glaeser, Edward L.; Kallal, Hedi D.; Scheinkman, José A.; Shleifer, Andrei (1992): Growth in Cities. In: *Journal of Political Economy* 100 (6), S. 1126–1152. DOI: 10.1086/261856.
55. Gold, Andrew H.; Malhotra, Arvind; Segars, Albert H. (2001): Knowledge Management: An Organizational Capabilities Perspective. In: *Journal of Management Information Systems* 18 (1), S. 185–214. DOI: 10.1080/07421222.2001.11045669.
56. Greve, H. R.; Baum, Joel A. C. (2009): Multiunit organization and multimarket strategy. Hg. v. Noel A. C. Baum. Bingley: Emerald Group Publishing Limited (Advances in strategic management, v. 18).
57. Griliches, Zvi (1992): The Search for R&D Spillovers. In: *The Scandinavian Journal of Economics* 94, S29. DOI: 10.2307/3440244.
58. Hall, Ronald L. (1979): Wittgenstein and Polanyi. In: *Philosophy Today* 23 (3), S. 267–278. DOI: 10.5840/philtoday197923319.
59. Hanson, Gordon (1994): Localization Economies, Vertical Organization and Trade. Cambridge, MA.
60. Harrison, Bennett (2007): Industrial Districts: Old Wine in New Bottles? (Volume 26, Number 5, 1992). In: *Regional Studies* 41 (sup1), S107-S121. DOI: 10.1080/00343400701232264.

61. Harrison, B., Kelley, M. R., & Gant, J. (1996): Specialization Versus Diversity in Local Economies: The Implicationis for Innovative Private-Sector Behaviour. In: *Cityscape* 2 (2), S. 61–93.

62. Henderson, J.Vernon (1997): Externalities and Industrial Development. In: *Journal of Urban Economics* 42 (3), S. 449–470. DOI: 10.1006/juec.1997.2036.

63. Henderson, J.Vernon (2003): Marshall's scale economies. In: *Journal of Urban Economics* 53 (1), S. 1–28. DOI: 10.1016/S0094-1190(02)00505-3.

64. Henderson, J.Vernon; Thisse, J. F. (Hg.) (2004): Cities and Geography: Elsevier (Handbook of Regional and Urban Economics).

65. Hippel, Eric von (1994): "Sticky Information" and the Locus of Problem Solving: Implications for Innovation. In: *Management Science* 40 (4), S. 429–439. DOI: 10.1287/mnsc.40.4.429.

66. Hult, G.Tomas M.; Hurley, Robert F.; Knight, Gary A. (2004): Innovativeness: Its antecedents and impact on business performance. In: *Industrial Marketing Management* 33 (5), S. 429–438. DOI: 10.1016/j.indmarman.2003.08.015.

67. Jacobs, Jane (1969): The Economy of Cities. 2. Aufl. New York: Random House Inc.

68. Jaffe, A. B.; Trajtenberg, M.; Henderson, R. (1993): Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations. In: *The Quarterly Journal of Economics* 108 (3), S. 577–598. DOI: 10.2307/2118401.

69. Jonas, Michael (2014): Zur Inszenierung eines Wirtschaftsclusters. Wiesbaden: Springer Fachmedien Wiesbaden.

70. Kaminski, Sandra (2009): Die regionale Clustermarke. Wiesbaden: Gabler.

71. Karlsson, Charlie; Manduchi, Agostino (2001): Knowledge Spillovers in a Spatial Context — A Critical Review and Assessment. In: Manfred M. Fischer und Josef Fröhlich (Hg.): Knowledge, Complexity and Innovation Systems. Berlin, Heidelberg: Springer Berlin Heidelberg (Advances in Spatial Science), S. 101–123.

72. Kiese, Matthias (Hg.) (2008): Cluster und Regionalentwicklung. Theorie, Beratung und praktische Umsetzung. Dortmund: Rohn.

73. Kobayashi, Kiyoshi (1995): Knowledge Network and Market Structure: An Analytical Perspective. In: David Batten, John Casti und Roland Thord (Hg.): Networks in Action. Berlin, Heidelberg: Springer Berlin Heidelberg, S. 127–158.

74. Kobayashi, Kiyoshi; Sunao, Seishin; Yoshikawa, Kazuhiro (1993): Spatial Equilibria of Knowledge Production with 'Meeting-Facilities'. In: David F. Batten, Åke E. Andersson, Kiyoshi Kobayashi und Kazuhiro Yoshikawa (Hg.): The Cosmo-Creative Society. Berlin, Heidelberg: Springer Berlin Heidelberg (Advances in Spatial and Network Economics), S. 219–244.

75. Krugman, Paul (1991a): Geography and Trade. 2. Aufl. Cambridge: MIT Press.

76. Krugman, Paul (1991b): Increasing Returns and Economic Geography. In: *Journal of Political Economy* 99 (3), S. 483–499. DOI: 10.1086/261763.

77. Kruskal, William H.; Wallis, W. Allen (1952): Use of Ranks in One-Criterion Variance Analysis. In: *Journal of the American Statistical Association* 47 (260), S. 583–621. DOI: 10.1080/01621459.1952.10483441.

78. Kukalis, Sal (2010): Agglomeration Economies and Firm Performance: The Case of Industry Clusters. In: *Journal of Management* 36 (2), S. 453–481. DOI: 10.1177/0149206308329964.

79. Lerch, Frank (2009): Netzwerkdynamiken im Cluster. Unter Mitarbeit von Universitätsbibliothek der FU Berlin.

80. Li, Jun; Geng, Shuai (2012): Industrial clusters, shared resources and firm performance. In: *Entrepreneurship & Regional Development* 24 (5-6), S. 357–381. DOI: 10.1080/08985626.2011.591841.

81. Lucas, Robert E. (1993): Making a Miracle. In: *Econometrica* 61 (2), S. 251. DOI: 10.2307/2951551.

82. Lundvall, Bengt-äke; Johnson, Björn (1994): The Learning Economy. In: *Journal of Industry Studies* 1 (2), S. 23–42. DOI: 10.1080/13662719400000002.

83. MacKinnon, Danny; Cumbers, Andrew (2011): Introduction to economic geography. Globalization, uneven development and place. 2nd edition. New York: Pearson Education.

84. Malmberg, Anders; Maskell, Peter (2006): Localized Learning Revisited. In: *Growth and Change* 37 (1), S. 1–18. DOI: 10.1111/j.1468-2257.2006.00302.x.

85. Malmberg, Anders; Sölvell, Örjan; Zander, Ivo (1996): Spatial Clustering, Local Accumulation of Knowledge and Firm Competitiveness. In: *Geografiska Annaler: Series B, Human Geography* 78 (2), S. 85–97. DOI: 10.1080/04353684.1996.11879699.

86. Marshall, Alfred (2014): Principles of Economics. New York, Gordonsville: Palgrave Macmillan; Macmillan [distributor] (Palgrave Classics in Economics Ser).

87. Martin, R.; Sunley, P. (2003): Deconstructing clusters: chaotic concept or policy panacea? In: *Journal of Economic Geography* 3 (1), S. 5–35. DOI: 10.1093/jeg/3.1.5.

88. Mathias, Blake D.; McCann, Brian T.; Whitman, Daniel S. (2021): A meta-analysis of agglomeration and venture performance: Firm-level evidence. In: *Strategic Entrepreneurship Journal* 15 (3), S. 430–453. DOI: 10.1002/sej.1390.

89. McFarland, Thomas W.; Yates, Jan M. (2016): Introduction to nonparametric statistics for the biological sciences using R. [Cham]: Springer.

90. Melo, Patricia C.; Graham, Daniel J.; Noland, Robert B. (2009): A meta-analysis of estimates of urban agglomeration economies. In: *Regional Science and Urban Economics* 39 (3), S. 332–342. DOI: 10.1016/j.regsciurbeco.2008.12.002.

91. Miller, Merton H. (1977): Debt and Taxes. In: *The Journal of Finance* 32 (2), S. 261. DOI: 10.2307/2326758.

92. Modigliani, Franco and Miller, Merton H. (1963): Corporate Income Taxes and the Cost of Capital: A Correction. In: *The American Economic Review* 53 (3), S. 433–443. Online verfügbar unter https://www.jstor.org/stable/1809167?casa_token=F7n6uh_1q7kAAAAA%3ABP8ihbE43QoJ5MyT-7GbUwr96BbYWHjpCMTf-rF7LTkO7j7xlfdF81N5xhBAZH_U0-

VILNY0ojXgCX1PUIqnXVKYv78RA4p9EmZPs5iyRYs-N3ASvfM#metadata_info_tab_contents.

93. Moodysson, Jerker; Zukauskaite, Elena (2014): Institutional Conditions and Innovation Systems: On the Impact of Regional Policy on Firms in Different Sectors. In: *Regional Studies* 48 (1), S. 127–138. DOI: 10.1080/00343404.2011.649004.

94. Mukkala, Kirsi (2004): Agglomeration economies in the finnish manufacturing sector. In: *Applied Economics* 36 (21), S. 2419–2427. DOI: 10.1080/0003684042000287655.

95. Müller, Werner A.; Bihn, Martina; Biffignandi, Silvia (1999): Micro- and Macrodata of Firms. Heidelberg: Physica-Verlag HD.

96. Myles Shaver, J.; Flyer, Fredrick (2000): Agglomeration economies, firm heterogeneity, and foreign direct investment in the United States. In: *Strat. Mgmt. J.* 21 (12), S. 1175–1193. DOI: 10.1002/1097-0266(200012)21:12<1175::AID-SMJ139>3.0.CO;2-Q.

97. Nellen, Oliver (op. 2004): Technologieförderung im Kontext betrieblicher Transformation. Eine Untersuchung für die neuen Bundesländer. Frankfurt am Main, Berlin, Bern [etc.]: P. Lang (Europäische Hochschulschriften. Reihe 5, Volks- und Betriebswirtschaft, Bd. 2926).

98. Nelson, Richard R. (1993): National innovation systems. A comparative analysis. New York: Oxford University Press.

99. NEWLANDS, DAVID (2003): Competition and Cooperation in Industrial Clusters: The Implications for Public Policy. In: *European Planning Studies* 11 (5), S. 521–532. DOI: 10.1080/09654310303649.

100. Oosterhaven, Jan; Eding, Gerard J.; Stelder, Dirk (2001): Clusters, Linkages and Interregional Spillovers: Methodology and Policy Implications for the Two Dutch Mainports and the Rural North. In: *Regional Studies* 35 (9), S. 809–822. DOI: 10.1080/00343400120090239.

101. Parr, John B. (2002a): Agglomeration Economies: Ambiguities and Confusions. In: *Environ Plan A* 34 (4), S. 717–731. DOI: 10.1068/a34106.

102. Parr, John B. (2002b): Missing Elements in the Analysis of Agglomeration Economies. In: *International Regional Science Review* 25 (2), S. 151–168. DOI: 10.1177/016001702762481221.

103. Pavelkova, Drahomira; Zizka, Miroslav; Homolka, Lubor; Knapkova, Adriana; Pelloneova, Natalie (2021): Do clustered firms outperform the non-clustered? Evidence of financial performance in traditional industries. In: *Economic Research-Ekonomska Istraživanja*, S. 1–23. DOI: 10.1080/1331677X.2021.1874460.

104. Pieper, Britta Verena (2013): Die Kunst des Clusterns. Wiesbaden: Springer Fachmedien Wiesbaden.

105. Polanyi, Michael (1967): Sense-Giving and Sense-Reading. In: *Philosophy* 42 (162), S. 301–325. DOI: 10.1017/S0031819100001509.

106. Polanyi, Michael; Nye, Mary Jo (2015): Personal knowledge. Towards post-critical philosophy. Enlarged ed. with a new foreword. Chicago, London: University of Chicago Press.

107. Porter, Michel E. (1990): The competitive advantage of nations. New York: The Free Press.

108. Porter, Michael E. (1998a): Clusters and the new economics of competition, S. 75–90. Online verfügbar unter https://www.biblioteca.fundacionicbc.edu.ar/images/d/de/Clusters_1.pdf, zuletzt geprüft am 17.07.2022.

109. Porter, Michael E. (1998b): The Adam Smith Address: Location, Clusters, and the "New" Microeconomics of Competition 33 (1), S. 7–13. Online verfügbar unter https://www.jstor.org/stable/23487685?seq=1, zuletzt geprüft am 26.06.2022.

110. Porter, Michael E. (1999): Wettbewerb und Strategie. München: Verlagshaus Goethestrasse [Econ].

111. Porter, Michael E. (2000): Location, Competition, and Economic Development: Local Clusters in a Global Economy. In: *Economic Development Quarterly* 14 (1), S. 15–34. DOI: 10.1177/089124240001400105.

112. Porter, Michael E. (2001): Clusters of innovation. Regional foundations of U.S. competitiveness. Washington, D.C.: Council on competitiveness.

113. Porter, Michael E. (2003): The Economic Performance of Regions. In: *Regional Studies* 37 (6-7), S. 549–578. DOI: 10.1080/0034340032000108688.

114. Porter, Michael E. (2006): On competition. 11. print. Boston, Mass.: Harvard Business School (The Harvard business review book series).

115. Power, Dominic; Lundmark, Mats (2004): Working through Knowledge Pools: Labour Market Dynamics, the Transference of Knowledge and Ideas, and Industrial Clusters. In: *Urban Studies* 41 (5-6), S. 1025–1044. DOI: 10.1080/00420980410001675850.

116. Prevezer, Martha (1997): The Dynamics of Industrial Clustering in Biotechnology. In: *Small Business Economics* 9 (3), S. 255–271. Online verfügbar unter https://www.jstor.org/stable/40228613.

117. Rigby, D. L.; Essletzbichler, J. (2002): Agglomeration economies and productivity differences in US cities. In: *Journal of Economic Geography* 2 (4), S. 407–432. DOI: 10.1093/jeg/2.4.407.

118. Romer, Paul M. (1986): Increasing Returns and Long-Run Growth. In: *Journal of Political Economy* 94 (5), S. 1002–1037. DOI: 10.1086/261420.

119. Romer, Paul M. (1990): Endogenous Technological Change. In: *Journal of Political Economy* 98 (5, Part 2), S71-S102. DOI: 10.1086/261725.

120. Romer, Paul M. (1994): The Origins of Endogenous Growth. In: *Journal of Economic Perspectives* 8 (1), S. 3–22. DOI: 10.1257/jep.8.1.3.

121. Rosenfeld, Stuart A. (1997): Bringing business clusters into the mainstream of economic development. In: *European Planning Studies* 5 (1), S. 3–23. DOI: 10.1080/09654319708720381.

122. Rozenbaum, Oded (2019): EBITDA and Managers' Investment and Leverage Choices. In: *Contemp Account Res* 36 (1), S. 513–546. DOI: 10.1111/1911-3846.12387.

123. Schiele, Holger (2003): Der Standort-Faktor. Wie Unternehmen durch regionale Cluster ihre Produktivität und Innovationskraft steigern. 1. Aufl. Weinheim: Wiley-VCH.

124. Schiele, Holger (2008): Location, location: the geography of industry clusters. In: *Journal of Business Strategy* 29 (3), S. 29–36. DOI: 10.1108/02756660810873191.

125. Schiele, Holger; Ebner, Alexander (2013): The Role of Domestic and International External Cluster Linkages Explored on the Example of Buyer–Supplier Relations in Learning Regions: A Cross-Functional Assessment. In: *European Planning Studies* 21 (5), S. 683–699. DOI: 10.1080/09654313.2013.734458.

126. Schiele, Holger; Harms, Rainer; Banerjee, Shrestho (2014): A national competitiveness-based portfolio approach for international strategic management: illustrated with the case of the TATA industries. In: *EJIM* 8 (1), Artikel 58494, S. 106. DOI: 10.1504/EJIM.2014.058494.

127. Schiele, Holger; Hospers, Gert-Jan; van der Zee, Debbie (2012): Surviving a cluster collapse: risk aversion as a core value. In: *Journal of Business Strategy* 33 (5), S. 14–21. DOI: 10.1108/02756661211282759.

128. Sforzi, Fabio (1990): The quantitative importance of Marshallian industrial districts in the Italian Economy.

129. Sforzi, Fabio (2002): The Industrial District and the 'New' Italian Economic Geography. In: *European Planning Studies* 10 (4), S. 439–447. DOI: 10.1080/09654310220130167.

130. Steinle, Claus; Schiele, Holger (2002): When do industries cluster? In: *Research Policy* 31 (6), S. 849–858. DOI: 10.1016/S0048-7333(01)00151-2.

131. Steinle, Claus; Schiele, Holger; Mietzner, Kai (2007): Merging a Firm-centred and a Regional Policy Perspective for the Assessment of Regional Clusters: Concept and Application of a “Dual” Approach to a Medical Technology Cluster. In: *European Planning Studies* 15 (2), S. 235–251. DOI: 10.1080/09654310601078762.

132. Sternberg, Rolf (1995): Wie entstehen High-Tech-Regionen? Theorretisch Erklärungen und empirische Befunde aus fünf Industriestaaten. In: *Geographische Zeitschrift* 83 (1), S. 48–63. Online verfügbar unter https://www.jstor.org/stable/27818707#metadata_info_tab_contents, zuletzt geprüft am 04.12.2022.

133. Stojčić, Nebojša; Anić, Ivan-Damir; Aralica, Zoran (2019): Do firms in clusters perform better? Lessons from wood-processing industries in new EU member states. In: *Forest Policy and Economics* 109, S. 102043. DOI: 10.1016/j.forpol.2019.102043.

134. Swann, Peter; Prevezer, Martha (1996): A comparison of the dynamics of industrial clustering in computing and biotechnology. In: *Research Policy* 25 (7), S. 1139–1157. DOI: 10.1016/S0048-7333(96)00897-9.

135. Teece, David J. (1980): Economies of scope and the scope of the enterprise. In: *Journal of Economic Behavior & Organization* 1 (3), S. 223–247. DOI: 10.1016/0167-2681(80)90002-5.

136. Teece, David J. (1981): The Market for Know-How and the Efficient International Transfer of Technology. In: *The ANNALS of the American Academy of Political and Social Science* 458 (1), S. 81–96. DOI: 10.1177/000271628145800107.

137. Teece, David J. (1998): Capturing Value from Knowledge Assets: The New Economy, Markets for Know-How, and Intangible Assets. In: *California Management Review* 40 (3), S. 55–79. DOI: 10.2307/41165943.

138. Thomi, Walter; Sternberg, Rolf (2008): Cluster – zur Dynamik von Begrifflichkeiten und Konzeptionen. In: *Zeitschrift für Wirtschaftsgeographie* 52 (1), S. 73–78. DOI: 10.1515/zfw.2008.0007.

139. van der Panne, Gerben (2004): Agglomeration externalities: Marshall versus Jacobs. In: *J. Evol. Econ.* 14 (5), S. 593–604. DOI: 10.1007/s00191-004-0232-x.

140. Visser, Evert-Jan (2009): The Complementary Dynamic Effects of Clusters and Networks. In: *Industry and Innovation* 16 (2), S. 167–195. DOI: 10.1080/13662710902764287.

141. Willig, Robert D. (1979): Multiproduct Technology and Market Structure. In: *The American Economic Review* 69 (2), S. 346–351.

142. Wixe, Sofia (2015): The Impact of Spatial Externalities: Skills, Education and Plant Productivity. In: *Regional Studies* 49 (12), S. 2053–2069. DOI: 10.1080/00343404.2014.891729.

143. Yoon, Eunju; Jang, SooCheong (2005): The Effect of Financial Leverage on Profitability and Risk of Restaurant Firms. In: *The Journal of Hospitality Financial Management* 13 (1), S. 35–47. DOI: 10.1080/10913211.2005.10653798.

144. Zürker, Matthias (2007): Cluster als neue Komponente der wirtschaftsbezogenen Raumentwicklung. Diskussionen der Anforderungen, Möglichkeiten und Grenzen des Ansatzes auf Basis der Erkenntnisse einer Ealuation der Clusterpolitik Oberösterreichs. Kaiserslautern: Selbstverlag, Lehrstuhl Regionalentwicklung und Raumordnung, Technische Universität Kaiserslautern (Materialien zur Regionalentwicklung und Raumordnung, Band 22).

10 Annexures

10.1 Financial KPI Definitions by Thomson Reuters EIKON

EBITDA Margin

EBITDA Margin (%) represents the ratio of Earnings before Interest, Taxes, Depreciation & Amortization (EBITDA) divided by the value of Revenue from business activities multiplied by 100. The denominator should be positive. It is applicable to all industries.

Total Debt % of Total Assets

Total debt % of total assets represents the ratio of total debt divided by the value of total assets multiplied by 100. It is applicable to all industries.

Return on Capital Employed (ROCE)

Return On Capital Employed (ROCE) is a financial ratio that measures a company's profitability and the efficiency with which its capital is employed. The ratio is calculated by dividing Earnings Before Interest and Tax (EBIT) by Capital Employed.

Return on average Common Equity

Return on average common equity (%) measures the ability of a company to generate earnings from its common stockholders' investments in the company. Return on average common equity represents the income available to common excluding extraordinary items shareholders equity multiplied by 100.

10.2 Python Algorithm

```python
# Haversine function to approximate the distance between two locations
from numpy import cos, sin, arcsin, sqrt
from math import radians

def haversine(lon1,lat1, lon2,lat2):
    lon1, lat1, lon2, lat2 = map(radians, [lon1, lat1, lon2, lat2])
    dlon = lon2 - lon1
    dlat = lat2 - lat1
    a = sin(dlat/2)**2 + cos(lat1) * cos(lat2) * sin(dlon/2)**2
    c = 2 * arcsin(sqrt(a))
    km = 6367 * c
    return km
```

```python
import pandas as pd
import numpy as np


df_firmdata = pd.read_excel('Input/Medical Equipment, Supplies & Distribution.xlsx')
df_firmdata.head()
firms = df_firmdata['Identifier'].unique()
```

```python
import pandas as pd
import numpy as np

for firm in firms:
    # Get lat/lng of current firm
    Ibase = df_firmdata['Identifier'] == firm
    baselat = df_firmdata.loc[Ibase, 'lat'].astype(float)
    baselng = df_firmdata.loc[Ibase, 'lng'].astype(float)
    # Loop through all other firms
    FirmsNearbyCount = 0 ## counts how many firms are within distance
    FirmsNearbyFiveKm = 0
    FirmsNearbyTenKm = 0
    FirmsNearbyFiveteenKm = 0
    FirmsNearbyTwentyKm = 0
    FirmsNearbyTwentyfiveKm = 0
    FirmsNearbyFiftyKm = 0

    for otherfirm in firms:
        if firm != otherfirm:
            Iother = df_firmdata['Identifier'] == otherfirm
            comparelat = df_firmdata.loc[Iother, 'lat'].astype(float)
            comparelng = df_firmdata.loc[Iother, 'lng'].astype(float)
            distance = haversine(baselat, baselng, comparelat, comparelng)
            if(distance) <= 1:
                FirmsNearbyCount = FirmsNearbyCount + 1
            if(distance) <= 5:
                FirmsNearbyFiveKm = FirmsNearbyFiveKm + 1
            if(distance) <= 10:
                FirmsNearbyTenKm = FirmsNearbyTenKm + 1
            if(distance) <= 15:
                FirmsNearbyFiveteenKm = FirmsNearbyFiveteenKm + 1
            if(distance) <= 20:
                FirmsNearbyTwentyKm = FirmsNearbyTwentyKm + 1
            if(distance) <= 25:
                FirmsNearbyTwentyfiveKm = FirmsNearbyTwentyfiveKm + 1
            if(distance) <= 50:
                FirmsNearbyFiftyKm = FirmsNearbyFiftyKm + 1

    df_firmdata.loc[Ibase, "FirmsNearbyOneKm"] =  FirmsNearbyCount
    df_firmdata.loc[Ibase, "FirmsNearbyFiveKm"] =  FirmsNearbyFiveKm
    df_firmdata.loc[Ibase, "FirmsNearbyTenKm"] =  FirmsNearbyTenKm
    df_firmdata.loc[Ibase, "FirmsNearbyFiveteenKm"] =  FirmsNearbyFiveteenKm
    df_firmdata.loc[Ibase, "FirmsNearbyTwentyKm"] =  FirmsNearbyTwentyKm
    df_firmdata.loc[Ibase, "FirmsNearbyTwentyfiveKm"] =  FirmsNearbyTwentyfiveKm
    df_firmdata.loc[Ibase, "FirmsNearbyFiftyKm"] =  FirmsNearbyFiftyKm
```

```
## Export to excel

df_firmdata.to_excel('Output/Medical Equipment, Supplies & Distribution.xlsx', index = None)
```

The Python workbook of the algorithm can be downloaded under the following link: Cluster Analysis. The individual input and output files need to be adjusted accordingly.

10.3 Data Overview

Industry Name	Number of Companies	Number of EBITDA Margins	Number of ROCE Margins	Number of Total Debt % of Asset Data Points	Number of Return on Average Common Equity - % Data Points
Advanced Medical Equipment & Technology	95	413	743	409	625
Advertising and Marketing	382	887	1363	703	1114
Aerospace & Defense	76	407	551	261	406
Agricultural Chemicals	42	258	321	228	251
Airlines	43	160	198	127	148
Airport Operators & Services	32	154	202	105	141
Aluminium	96	356	594	334	413
Apparel & Accessories	233	698	1120	643	993
Apparel & Accessories Retailers	262	563	1161	633	1059
Appliances, Tools & Houseware	178	410	659	368	619
Auto & Truck Manufacturers	239	877	0	1075	0
Auto Vehicles, Parts & Service Retailers	417	1135	1887	1703	1704
Auto, Truck and Motorcycle Parts	202	875	1000	825	882
Banks	355	1628	2458	2026	2777
Biotechnology & Medical Research	177	575	793	399	657
Brewers	27	167	240	162	225
Broadcasting	35	79	91	48	90
Business Support Services	2288	4346	5853	3115	4811

Business Support Supplies	177	347	675	353	608
Casinos & Gaming	43	183	216	109	204
Commercial Printing Services	252	452	884	630	767
Commodity Chemicals	970	3214	5708	3441	4691
Communications & Networking	67	277	362	180	297
Computer & Electronics Retailers	42	161	208	126	180
Computer Hardware	190	634	1026	513	825
Construction & Engineering	1990	3051	6485	3559	5541
Construction Materials	509	1203	2300	1494	1902
Construction Supplies & Fixtures	538	1067	2232	1424	1970
Consumer Lending	38	163	212	146	195
Consumer Publishing	344	659	1077	402	911
Corporate Financial Services	174	1220	1304	1031	1162
Courier, Postal, Air Freight & Land-based logistics	556	1309	2196	1303	1855
Department Stores	100	296	347	233	287
Discount Stores	33	141	256	49	235
Distillers & Wineries	125	305	462	325	432
Diversified Chemicals	16	124	163	146	136
Diversified Industrial Goods Wholesale	34	236	282	180	251
Diversified Investment Services	22	187	215	167	205
Drug Retailers	75	232	317	146	257
Electric Utilities	384	3373	3385	2600	2141

Electrical Components & Equipment	765	2204	3854	2180	3243
Electronic Equipment & Parts	205	671	1173	709	1010
Employment Services	473	554	1117	435	972
Entertainment Production	92	313	362	233	300
Environmental Services & Equipment	175	615	836	595	696
Financial & Commodity Market Operators	24	118	147	111	142
Financial Technology	13	61	80	30	61
Fishing & Farming	343	886	1556	1121	1440
Food Processing	1159	2240	3963	2850	3443
Food Retail & Distribution	440	655	919	598	819
Footwear	45	175	224	182	208
Forest & Wood Products	166	357	634	480	548
Ground Freight & Logistics	246	413	667	452	565
Healthcare Facilities & Services	1385	4888	5179	3844	4592
Heavy Electrical Equipment	166	579	846	493	708
Heavy Machinery and Vehicle	274	1125	1720	1136	1425
Highways & Rail Trucks	44	231	242	151	166
Home Furnishing	262	402	703	507	630
Home Furnishing Retailers	31	100	165	119	143
Home Improvement Products & Service Retailers	54	138	158	138	151
Hotels, Motels & Cruise Lines	247	418	697	344	502
Household Electronics	86	307	415	122	323

Household Products	37	107	187	100	168
Independent Power Producers	35	356	340	269	265
Industrial Machinery & Equipment	2083	6287	11248	6854	9687
Integrated Hardware & Software	6	5	18	4	13
Integrated Telecommunication Services	81	368	427	279	365
Investment Banking & Brokerage Services	27	161	213	110	190
Investment Holding Companies	720	5042	5241	4465	4910
Investment Management & Fund Operators	218	1094	1316	851	1160
Iron & Steel	610	2013	3210	2191	2717
IT Services & Consulting	577	1612	2273	1034	1894
Leisure & Recreation	377	882	1313	809	1047
Life & Health Insurance	144	82	655	137	481
Marine Freight & Logistics	71	267	332	167	271
Marine Port Services	30	123	136	92	102
Medical Equipment, Supplies & Distribution	303	850	1589	839	1280
Mining Support Services	48	196	305	208	253
Miscellaneous Specialty Retailers	172	411	726	428	657
Multiline Insurance & Brokers	84	168	475	161	352
Multiline Utilities	43	478	450	346	271
Natural Gas Utilities	30	263	272	174	227
Non-Alcoholic Beverages	99	336	512	377	438
Non-Gold Precious Metals & Minerals	30	154	162	138	146
Non-Paper Containers & Packaging	149	329	749	450	635

Office Equipment	86	341	481	262	411
Oil & Gas Refining and Marketing	114	417	528	313	417
Oil & Gas Transportation Services	38	149	232	122	169
Online Services	88	308	323	207	295
Paper Packaging	91	160	271	173	219
Paper Products	119	497	650	407	526
Passenger Transportation Ground & Sea	315	752	974	710	654
Personal Products	155	294	679	342	584
Personal Services	1043	1448	1940	1265	1702
Pharmaceuticals	214	1065	1397	763	1067
Professional Information Services	95	142	219	69	163
Property & Casualty Insurance	33	0	210	28	136
Real Estate Rental, Development & Operations	144	760	760	733	730
Real Estate Services	145	458	504	361	434
Recreational Products	67	174	340	205	302
Renewable Energy Equipment & Services	43	237	242	207	201
Restaurants & Bars	345	339	606	328	474
Semiconductors	56	287	347	274	324
Software	490	1306	1780	916	1483
Speciality Chemicals	73	365	526	325	431
Speciality Mining and Metals	162	472	766	487	673
Textiles and Leather Goods	169	394	783	493	675

Tires and Rubber Products	85	283	455	271	344
Toys & Children Products	38	137	208	137	187
Water & Related Utilities	130	429	419	297	278
Wireless Telecommunication Services	9	20	20	20	20
Sum	**28.874**	**83.090**	**123.012**	**78.749**	**104.482**

10.4 Kruskal-Wallis Results Overview

The individual data files are uploaded as Excel files and can be found in the following Google Drive link.

The individual results of the Kruskal-Wallis ANOVA calculations can be found in the following Google Drive link.

The overview of the ANOVA results for each KPI and industry can be found in the following Google Drive link.

10.4.1.1 Empirical results of ANOVA with respect to the EBITDA margins

	3 Year Average			5 Year Average			10 Year Average		
Industry	5 km	15 km	25 km	5 km	15 km	25 km	5 km	15 km	25 km
Advanced Medical Equipment & Technology	0,012	0,074	0,217	0,012	0,063	0,151	0,044	0,079	0,333
Advertising & Marketing	0,024	0,039	0,110	0,097	0,033	0,083	0,711	0,386	0,121
Aerospace & Defense	0,036	0,039	0,033	0,209	0,123	0,060	0,186	0,211	0,328
Agricultural Chemicals	0,563	0,563	0,823	0,210	0,210	0,640	0,637	0,637	0,934
Airlines	0,710	0,111	0,191	0,153	0,258	0,437	0,655	0,413	0,622
Airport Operators & Services	0,611	0,273	0,273	0,693	0,273	0,273	0,810	0,276	0,276
Aluminum	0,184	0,106	0,851	0,223	0,150	0,696	0,237	0,024	0,984
Apparel & Accessories	0,599	0,096	0,077	0,410	0,104	0,076	0,276	0,273	0,272
Apparel & Accessories Retailers	0,214	0,167	0,084	0,199	0,266	0,151	0,716	0,308	0,212
Appliances, Tools & Houseware	0,950	0,927	0,996	0,958	0,680	0,936	0,990	0,683	0,884
Auto & Truck Manufacturers	0,312	0,118	0,078	0,117	0,191	0,176	0,292	0,474	0,283
Auto Vehicles, Parts & Service Retailers	0,324	0,642	0,583	0,370	0,710	0,625	0,214	0,904	0,416
Auto, Truck & Motorcycle Parts	0,514	0,065	0,143	0,502	0,196	0,232	0,939	0,435	0,147
Banks	0,864	0,803	0,803	0,769	0,804	0,804	0,104	0,493	0,448
Biotechnology & Medical Research	0,030	0,006	0,009	0,015	0,006	0,012	0,252	0,044	0,075

Brewers	0,296	0,296	0,296	0,283	0,283	0,283	0,667	0,667	0,667
Broadcasting	0,879	0,879	0,852	0,807	0,807	0,852	0,287	0,287	0,538
Business Support Services	0,098	0,946	0,756	0,253	0,256	0,071	0,059	0,089	0,018
Business Support Supplies	0,957	0,198	0,514	0,923	0,326	0,116	0,702	0,506	0,058
Casinos & Gaming	0,661	0,757	0,896	0,961	0,542	0,640	0,570	0,988	0,786
Commercial Printing Services	0,311	0,556	0,645	0,582	0,647	0,610	0,342	0,368	0,607
Commodity Chemicals	0,566	0,950	0,530	0,159	0,777	0,433	0,026	0,223	0,087

Communications & Networking	0,353	0,980	0,655	0,310	0,271	0,486	0,170	0,383	0,212
Computer & Electronics Retailers	0,855	0,961	0,630	0,855	0,972	0,740	0,667	0,870	0,660
Computer Hardware	0,567	0,567	0,563	0,569	0,774	0,175	0,250	0,139	0,050
Construction & Engineering	0,148	0,020	0,010	0,318	0,080	0,036	0,348	0,323	0,082
Construction Materials	0,138	0,669	0,329	0,110	0,437	0,185	0,220	0,662	0,115
Construction Supplies & Fixtures	0,321	0,598	0,187	0,228	0,404	0,086	0,192	0,233	0,021
Consumer Lending	0,157	0,157	0,248	0,355	0,343	0,304	0,643	0,287	0,343
Consumer Publishing	0,600	0,089	0,030	0,643	0,068	0,016	0,443	0,038	0,043
Corporate Financial Services	0,750	0,380	0,510	0,336	0,757	0,411	0,103	0,447	0,119
Courier, Postal, Air Freight & Land-based logistics	0,614	0,152	0,086	0,455	0,108	0,070	0,706	0,031	0,024
Department Stores	0,376	0,110	0,091	0,409	0,020	0,023	0,404	0,053	0,024
Discount Stores			0,772	0,188	0,188	0,421	0,593	0,593	0,593
Distillers & Wineries	0,279	0,570	0,520	0,238	0,379	0,341	0,094	0,172	0,151
Diversified Chemicals									
Diversified Industrial Goods Wholesale	0,493	0,712	0,832	0,725	0,908	0,861	0,533	0,563	0,961
Diversified Investment Services	0,031	0,310	0,310	0,067	0,548	0,548	0,031	0,495	0,495
Drug Retailers	0,034	0,494	0,493	0,035	0,385	0,336	0,230	0,872	0,220
Electric Utilities	0,033	0,023	0,149	0,063	0,025	0,070	0,140	0,030	0,006
Electrical Components & Equipment	0,147	0,578	0,348	0,412	0,782	0,201	0,085	0,983	0,620
Electronic Equipment & Parts	0,264	0,224	0,089	0,257	0,126	0,075	0,247	0,717	0,172
Employment Services	0,196	0,120	0,358	0,100	0,070	0,380	0,158	0,150	0,565
Entertainment Production	0,172	0,254	0,231	0,122	0,145	0,092	0,163	0,319	0,284
Environmental Services & Equipment	0,064	0,091	0,210	0,076	0,052	0,288	0,074	0,239	0,525
Financial & Commodity Market Operators & Services									
Financial Technology	0,564	0,564							
Fishing & Farming	0,207	0,233	0,148	0,180	0,328	0,098	0,331	0,905	0,378
Food Processing	0,361	0,277	0,960	0,694	0,232	0,922	0,991	0,011	0,142

Food Retail & Distribution	0,863	0,852	0,821	0,473	0,512	0,321	0,190	0,458	0,346
Footwear	0,227	0,035	0,054	0,227	0,078	0,091	0,632	0,104	0,198
Forest & Wood Products	0,845	0,868	0,615	0,803	0,814	0,963	0,602	0,877	0,448
Ground Freight & Logistics	0,158	0,135	0,133	0,126	0,073	0,072	0,659	0,206	0,129
Healthcare Facilities & Services	0,029	0,056	0,410	0,581	0,301	0,825	0,762	0,117	0,136
Heavy Electrical Equipment	0,444	0,074	0,498	0,203	0,061	0,210	0,288	0,229	0,370
Heavy Machinery & Vehicles	0,597	0,416	0,038	0,686	0,386	0,019	0,651	0,716	0,243
Highways & Rail Trucks	0,625	0,669	0,646	0,885	0,685	0,722	0,043	0,340	0,069
Home Furnishing	0,310	0,375	0,913	0,293	0,628	0,220	0,662	0,174	0,825
Home Furnishing Retailers	0,132	0,135	0,135	0,132	0,135	0,135	0,300	0,300	0,300
Home Improvement Products & Service Retail	0,909	0,909	0,909	0,909	0,909	0,909	0,909	0,909	0,909
Hotels, Motels & Cruise Lines	0,103	0,467	0,260	0,085	0,094	0,063	0,209	0,212	0,142
Household Electronics	0,028	0,965	0,360	0,042	0,863	0,583	0,142	0,858	0,832
Household Products		0,245	0,245		0,513	0,513		0,513	0,768
Independent Power Producers	0,032	0,724	0,604	0,028	0,653	0,696	0,031	0,609	0,696
Industrial Machinery & Equipment	0,131	0,028	0,029	0,108	0,037	0,121	0,722	0,182	0,150
Integrated Hardware & Software									
Integrated Telecommunication Services	0,939	0,387	0,181	0,927	0,564	0,220	0,799	0,496	0,277
Investment Banking & Brokerage Services	0,187	0,439	0,624	0,187	0,439	0,624	0,254	0,796	0,865
Investment Holding Companies	0,127	0,686	0,550	0,417	0,391	0,603	0,033	0,865	0,635
Investment Management & Fund Operators	0,201	0,417	0,633	0,044	0,102	0,169	0,125	0,212	0,333
Iron & Steel	0,481	0,711	0,595	0,404	0,373	0,619	0,090	0,176	0,982
IT Services & Consulting	0,681	0,777	0,990	0,624	0,551	0,763	0,471	0,181	0,345
Leisure & Recreation	0,073	0,100	0,061	0,101	0,110	0,073	0,294	0,082	0,038
Life & Health Insurance	1,000	1,000	0,819	0,770	0,770	0,538	0,424	0,424	0,456
Marine Freight Logistics	0,007	0,002	0,002	0,317	0,125	0,125	0,614	0,756	0,756
Marine Port Services	0,117	0,331	0,296	0,117	0,331	0,296	0,223	0,511	0,305

Medical Equipment, Supplies & Distribution	0,735	0,122	0,234	0,580	0,084	0,217	0,797	0,133	0,266
Mining Support Services & Equipment	0,441	0,111	0,424	0,801	0,191	0,441	0,697	0,257	0,406
Miscellaneous Specialty Retailers	0,293	0,465	0,925	0,152	0,651	0,879	0,431	0,732	0,892
Multiline Insurance & Brokers	0,343	0,440	0,741	0,430	0,849	0,849	0,823	0,441	0,441
Multiline Utilities	0,065	0,507	0,065	0,052	0,366	0,102	0,016	0,480	0,165
Natural Gas Utilities	0,615	0,697	0,823	0,546	0,640	0,709	0,427	0,741	0,782
Non-Alcoholic Beverages	0,264	0,300	0,938	0,305	0,361	0,580	0,553	0,293	0,443
Non-Gold Precious Metals & Minerals	0,111	0,195	0,569	0,192	0,306	0,261	0,111	0,103	0,476
Non-Paper Containers & Packaging	0,860	0,179	0,135	0,714	0,351	0,099	0,487	0,171	0,361
Office Equipment	0,158	0,167		0,094	0,127	0,577	0,498	0,162	0,386
Oil & Gas Refining and Marketing	0,304	0,410	0,590	0,434	0,458	0,743	0,615	0,641	0,793
Oil & Gas Transportation Services	0,223	0,223	0,223	0,099	0,099	0,099	0,059	0,059	0,059
Online Services	0,284	0,437	0,091	0,181	0,353	0,130	0,205	0,129	0,038
Paper Packaging	0,710	0,846	0,940	1,000	0,684	0,770	0,423	0,238	0,412
Paper Products	0,763	0,647	0,729	0,639	0,356	0,846	0,698	0,155	0,914
Passenger Transportation, Ground & Sea	0,586	0,653	0,036	0,871	0,982	0,093	0,546	0,840	0,080
Personal Products	0,875	0,306	0,286	0,772	0,496	0,380	0,751	0,996	0,675
Personal Services	0,490	0,803	0,253	0,872	0,817	0,475	0,513	0,697	0,559
Pharmaceuticals	0,180	0,709	0,243	0,267	0,311	0,128	0,369	0,092	0,017
Professional Information Services	0,751	0,333	0,460	0,519	0,193	0,193	0,830	0,442	0,442
Property & Casualty Insurance									
Real Estate Rental, Developmennt & Operations	0,096	0,139	0,037	0,264	0,406	0,102	0,834	0,706	0,239
Real Estate Services	0,837	0,592	0,258	0,951	0,671	0,270	0,991	0,750	0,742
Recreational Products	0,456	0,734	0,345	0,734	0,501	0,345	0,734	0,086	0,066
Renewable Energy Equipment & Services		0,772	0,949		0,759	0,974		0,187	0,952
Restaurants & Bars	0,180	0,036	0,062	0,240	0,175	0,231	0,115	0,011	0,021
Semiconductors	0,271	0,039	0,115	0,225	0,022	0,080	0,168	0,068	0,174

Software	0,827	0,989	0,593	0,703	0,915	0,979	0,300	0,822	0,952
Specialty Chemicals	0,239	0,885	0,868	0,300	0,519	0,871	0,358	0,628	0,312
Specialty Mining & Metals	0,596	0,596	0,683	0,631	0,536	0,791	0,852	0,963	0,924
Textiles & Leather Goods	0,227	0,791	0,321	0,143	0,765	0,486	0,063	0,508	0,433
Tires & Rubber Products	0,688	0,864		0,253	0,648	0,950	0,221	0,465	0,389
Toys & Childrens Products	0,667	0,789	0,282	0,519	0,378	0,282	0,480	0,306	0,165
Water & Related Utilities	0,979	0,804	0,464	0,948	0,729	0,421	0,933	0,612	0,375

Values < 0,05	11	10	9	6	6	5	7	7	10
Relation < 0,05	10,7%	9,5%	8,7%	5,8%	5,7%	4,8%	6,8%	6,7%	9,5%
Values ≥ 0,05	92	95	94	97	99	100	96	98	95
Relation ≥ 0,05	89,3%	90,5%	91,3%	94,2%	94,3%	95,2%	93,2%	93,3%	90,5%
Total Values	103	105	103	103	105	105	103	105	105

10.4.1.2 *Empirical results of ANOVA with respect to the ROCE margins*

	3 Year Average			5 Year Average			10 Year Average		
Industry	5 km	15 km	25 km	5 km	15 km	25 km	5 km	15 km	25 km
Advanced Medical Equipment & Technology	0,522	0,137	0,012	0,449	0,682	0,044	0,095	0,920	0,185
Advertising & Marketing	0,336	0,447	0,562	0,515	0,337	0,225	0,876	0,933	0,730
Aerospace & Defense	0,013	0,047	0,011	0,060	0,092	0,022	0,086	0,093	0,223
Agricultural Chemicals	0,618	0,351	0,595	0,028	0,028	0,139	0,025	0,025	0,097
Airlines	0,763	0,020	0,021	0,863	0,057	0,113	0,637	0,121	0,234
Airport Operators & Services	0,400	0,239	0,239	0,814	0,237	0,237	0,673	0,212	0,212
Aluminum	0,165	0,327	0,589	0,316	0,452	0,900	0,762	0,365	0,965
Apparel & Accessories	0,123	0,427	0,272	0,098	0,141	0,075	0,396	0,452	0,175
Apparel & Accessories Retailers	0,281	0,858	0,132	0,412	0,934	0,201	0,523	0,944	0,514
Appliances, Tools & Houseware	0,445	0,669	0,752	0,556	0,543	0,511	0,641	0,488	0,203
Auto & Truck Manufacturers									
Auto Vehicles, Parts & Service Retailers	0,340	0,494	0,246	0,275	0,469	0,309	0,924	0,205	0,660
Auto, Truck & Motorcycle Parts	0,106	0,124	0,451	0,084	0,070	0,515	0,573	0,296	0,083
Banks	0,870	0,916	0,992	0,165	0,366	0,308	0,068	0,026	0,030
Biotechnology & Medical Research	0,818	0,743	0,605	0,766	0,388	0,493	0,257	0,756	0,504
Brewers	0,160	0,160	0,767	0,232	0,232	0,911	0,074	0,074	0,074
Broadcasting	0,526	0,526	0,501	0,424	0,424	0,485	0,486	0,486	0,359
Business Support Services	0,443	0,180	0,180	0,607	0,341	0,170	0,397	0,129	0,017
Business Support Supplies	0,002	0,682	0,887	0,008	0,722	0,745	0,047	0,848	0,433
Casinos & Gaming	0,228	0,053	0,063	0,036	0,016	0,017	0,045	0,306	0,205
Commercial Printing Services	0,108	0,772	0,595	0,172	0,811	0,534	0,138	0,417	0,429
Commodity Chemicals	0,632	0,893	0,574	0,773	0,990	0,556	0,115	0,717	0,793
Communications & Networking	0,994	0,969	0,839	0,948	0,598	0,459	0,834	0,813	0,282
Computer & Electronics Retailers	1,000	0,929	0,780	1,000	0,968	0,920	0,881	0,910	0,649
Computer Hardware	0,290	0,934	0,873	0,452	0,965	0,737	0,285	0,797	0,724

Construction & Engineering	0,001	0,001	0,003	0,015	0,004	0,006	0,020	0,249	0,042
Construction Materials	0,147	0,827	0,610	0,093	0,776	0,108	0,687	0,983	0,468
Construction Supplies & Fixtures	0,443	0,262	0,340	0,406	0,081	0,177	0,400	0,389	0,048
Consumer Lending	0,195	0,659	0,569	0,185	0,590	0,582	0,327	0,643	0,390
Consumer Publishing	0,486	0,077	0,040	0,830	0,088	0,198	0,930	0,184	0,832
Corporate Financial Services	0,588	0,932	0,291	0,539	0,782	0,112	0,352	0,944	0,804
Courier, Postal, Air Freight & Land-based logistics	0,482	0,646	0,404	0,629	0,686	0,475	0,524	0,284	0,005
Department Stores	0,056	0,067	0,107	0,361	0,097	0,070	0,189	0,023	0,023
Discount Stores	0,329	0,329	0,329	0,166	0,166	0,223	0,531	0,531	0,127
Distillers & Wineries	0,309	0,322	0,167	0,323	0,228	0,303	0,149	0,080	0,172
Diversified Chemicals									
Diversified Industrial Goods Wholesale	0,746	0,694	0,949	0,375	0,561	0,541	0,948	0,129	0,566
Diversified Investment Services	0,761	0,761	0,130	0,926	0,926	0,183	0,645	0,645	0,109
Drug Retailers	0,217	0,835	0,849	0,471	0,567	0,649	0,829	0,537	0,470
Electric Utilities	0,573	0,820	0,401	0,584	0,866	0,217	0,264	0,793	0,030
Electrical Components & Equipment	0,018	0,074	0,298	0,181	0,123	0,378	0,180	0,111	0,685
Electronic Equipment & Parts	0,130	0,172	0,068	0,182	0,252	0,122	0,380	0,574	0,412
Employment Services	0,631	0,021	0,096	0,248	0,193	0,238		0,824	0,926
Entertainment Production	0,219	0,383	0,405	0,266	0,216	0,983	0,243	0,183	0,479
Environmental Services & Equipment	0,416	0,821	0,233	0,494	0,763	0,409	0,336	0,475	0,377
Financial & Commodity Market Operators & Services									
Financial Technology									
Fishing & Farming	0,149	0,034	0,022	0,527	0,270	0,135	0,912	0,540	0,028
Food Processing	0,162	0,719	0,180	0,177	0,727	0,341	0,939	0,763	0,350
Food Retail & Distribution	0,040	0,270	0,031	0,010	0,242	0,016	0,014	0,191	0,096
Footwear	0,347	0,427	0,386	0,240	0,238	0,232	0,810	0,271	0,409
Forest & Wood Products	0,486	0,642	0,903	0,418	0,257	0,893	0,174	0,226	0,682

Ground Freight & Logistics	0,529	0,093	0,120	0,594	0,045	0,130	0,060	0,567	0,836
Healthcare Facilities & Services	0,009	0,040	0,121	0,085	0,043	0,159	0,004	0,001	0,004
Heavy Electrical Equipment	0,498	0,048	0,612	0,442	0,050	0,329	0,085	0,094	0,426
Heavy Machinery & Vehicles	0,203	0,022	0,641	0,204	0,035	0,611	0,092	0,032	0,765
Highways & Rail Trucks	0,573	0,417	0,092	0,792	0,311	0,311	0,274	0,338	0,308
Home Furnishing	0,354	0,434	0,747	0,502	0,291	0,696	0,994	0,804	0,751
Home Furnishing Retailers	0,178	0,137	0,137	0,231	0,259	0,259	0,186	0,179	0,179
Home Improvement Products & Service Retail	0,558	0,690	0,712	0,661	0,564	0,547	0,372	0,265	0,265
Hotels, Motels & Cruise Lines	0,009	0,089	0,041	0,008	0,374	0,221	0,006	0,475	0,204
Household Electronics	0,336	0,568	0,309	0,278	0,863	0,489	1,000	0,482	0,625
Household Products	0,105	0,062	0,065	0,104	0,266	0,084		0,901	0,273
Independent Power Producers	0,123	0,125	0,754	0,076	0,136	0,892	0,220	0,612	0,586
Industrial Machinery & Equipment	0,044	0,518	0,290	0,101	0,792	0,197	0,975	0,223	0,076
Integrated Hardware & Software									
Integrated Telecommunication Services	0,106	0,079	0,113	0,273	0,066	0,092	0,738	0,322	0,306
Investment Banking & Brokerage Services	0,764	0,908	0,743	0,678	0,923	0,847	0,803	0,564	0,938
Investment Holding Companies	0,197	0,178	0,009	0,104	0,234	0,020	0,036	0,633	0,179
Investment Management & Fund Operators	0,187	0,593	0,823	0,269	0,707	0,735	0,014	0,123	0,128
Iron & Steel	0,045	0,055	0,030	0,121	0,103	0,224	0,205	0,588	0,620
IT Services & Consulting	0,500	0,781	0,528	0,917	0,670	0,523	0,466	0,069	0,041
Leisure & Recreation	0,607	0,898	0,493	0,612	0,818	0,712	0,888	0,350	0,411
Life & Health Insurance	0,088	0,288	0,174	0,257	0,193	0,156	0,630	0,667	0,549
Marine Freight Logistics	0,480	0,409	0,409	0,567	0,478	0,478	0,176	0,325	0,325
Marine Port Services	0,693	0,735	0,735	1,000	0,593	0,814	0,885	0,474	0,405
Medical Equipment, Supplies & Distribution	0,883	0,681	0,195	0,910	0,455	0,185	0,152	0,246	0,554
Mining Support Services & Equipment	0,631	0,540	0,462	0,570	0,298	0,237	0,933	0,180	0,573
Miscellaneous Specialty Retailers	0,826	0,686	0,286	0,811	0,614	0,405	0,761	0,850	0,681

Multiline Insurance & Brokers	0,292	0,345	0,345	0,442	0,272	0,272	0,383	0,138	0,203
Multiline Utilities	0,218	0,881	0,380	0,352	0,940	0,604	0,282	0,911	0,600
Natural Gas Utilities	0,534	0,597	0,733	0,738	0,698	0,785	0,584	0,688	0,796
Non-Alcoholic Beverages	0,174	0,460	0,365	0,041	0,323	0,778	0,029	0,102	0,718
Non-Gold Precious Metals & Minerals	0,710	0,504	0,241	0,710	0,544	0,226	0,107	0,548	0,552
Non-Paper Containers & Packaging	0,738	0,019	0,354	0,961	0,010	0,533	0,662	0,185	0,755
Office Equipment	0,818	0,488	0,785	0,767	0,553	0,965	0,529	0,915	0,540
Oil & Gas Refining and Marketing	0,483	0,684	0,661	0,372	0,464	0,633	0,393	0,669	0,279
Oil & Gas Transportation Services	0,193	0,193	0,371	0,801	0,801	0,724	0,905	0,905	0,993
Online Services	0,662	0,983	0,755	0,165	0,675	0,316	0,743	0,772	0,282
Paper Packaging	0,850	0,789	0,650	0,933	0,545	0,745	0,694	0,106	0,654
Paper Products	0,408	0,335	0,510	0,439	0,059	0,210	0,218	0,097	0,027
Passenger Transportation, Ground & Sea	0,557	0,539	0,714	0,356	0,524	0,386	0,313	0,401	0,379
Personal Products	0,221	0,270	0,148	0,199	0,263	0,134	0,614	0,949	0,626
Personal Services	0,570	0,804	0,180	0,117	0,750	0,271	0,374	0,815	0,559
Pharmaceuticals	0,126	0,167	0,534	0,262	0,348	0,716	0,087	0,384	0,523
Professional Information Services	0,388	0,611	0,611	0,479	0,829	0,829	0,587	0,731	0,731
Property & Casualty Insurance	0,084	0,332	0,212	0,111	0,445	0,355	0,352	0,437	0,673
Real Estate Rental, Developmennt & Operations	0,981	0,151	0,477	0,819	0,033	0,037	0,634	0,054	0,407
Real Estate Services	0,209	0,449	0,217	0,245	0,620	0,350	0,162	0,311	0,220
Recreational Products	0,067	0,418	0,128	0,058	0,546	0,249	0,491	0,594	0,319
Renewable Energy Equipment & Services		0,476	0,930		0,612	0,919		0,376	0,466
Restaurants & Bars	0,712	0,088	0,099	0,461	0,412	0,635	0,982	0,119	0,229
Semiconductors	0,952	0,145	0,546	0,934	0,026	0,304	0,810	0,128	0,141
Software	0,437	0,311	0,033	0,510	0,476	0,083	0,894	0,838	0,279
Specialty Chemicals	0,834	0,508	0,281	0,952	0,482	0,423	0,810	0,196	0,150
Specialty Mining & Metals	0,611	0,933	0,375	0,473	0,675	0,873	0,209	0,442	0,056

Textiles & Leather Goods	0,812	0,543	0,672	0,827	0,649	0,562	0,768	0,534	0,389
Tires & Rubber Products	1,000	0,618	0,322	0,920	0,749	0,647	0,524	0,331	0,747
Toys & Childrens Products	0,491	0,990	0,471	0,368	0,999	0,471	0,953	0,943	0,388
Water & Related Utilities	0,883	0,666	0,386	0,915	0,841	0,490	0,351	0,798	0,306
Values < 0,05	9	9	11	7	9	7	10	5	11
Relation < 0,05	8,7%	8,6%	10,5%	6,7%	8,6%	6,7%	9,8%	4,8%	10,5%
Values ≥ 0,05	95	96	94	97	96	98	92	100	94
Relation ≥ 0,05	91,3%	91,4%	89,5%	93,3%	91,4%	93,3%	90,2%	95,2%	89,5%
Total Values	104	105	105	104	105	105	102	105	105

10.4.1.3 *Empirical results of ANOVA with respect to the ROE margins*

Industry	3 Year Average 5 km	15 km	25 km	5 Year Average 5 km	15 km	25 km	10 Year Average 5 km	15 km	25 km
Advanced Medical Equipment & Technology	0,221	0,375	0,048	0,202	0,653	0,028	0,008	0,706	0,086
Advertising & Marketing	0,723	0,965	0,839	0,153	0,765	0,349	0,347	0,496	0,266
Aerospace & Defense	0,060	0,189	0,038	0,252	0,525	0,149	0,339	0,698	0,222
Agricultural Chemicals	0,191	0,049	0,049	0,232	0,232	0,232	0,667	0,667	0,667
Airlines	0,248	0,045	0,032	0,401	0,151	0,116	0,364	0,364	0,555
Airport Operators & Services	0,830	0,830	0,830	0,519	0,519	0,519	0,518	0,518	0,518
Aluminum	0,288	0,909	0,948	0,325	0,484	0,644	0,274	0,849	0,726
Apparel & Accessories	0,552	0,462	0,270	0,688	0,487	0,553	0,082	0,606	0,248
Apparel & Accessories Retailers	0,792	0,941	0,114	0,564	0,995	0,110	0,368	0,357	0,271
Appliances, Tools & Houseware	0,642	0,861	0,755	0,874	0,751	0,453	0,873	0,649	0,251
Auto & Truck Manufacturers									
Auto Vehicles, Parts & Service Retailers	0,266	0,316	0,188	0,459	0,148	0,137	0,672	0,168	0,361
Auto, Truck & Motorcycle Parts	0,323	0,200	0,456	0,215	0,137	0,333	0,736	0,907	0,262
Banks	0,007	0,001	0,001	0,001	0,001	0,001	0,001	0,001	0,001
Biotechnology & Medical Research	0,785	0,654	0,447	0,703	0,833	0,718	0,236	0,953	0,281
Brewers	0,233	0,233	0,044	0,352	0,352	0,219	0,233	0,233	0,233
Broadcasting	0,931	0,931	0,538	0,807	0,807	0,570	0,801	0,801	0,407
Business Support Services	0,537	0,297	0,232	0,326	0,320	0,280	0,070	0,227	0,276
Business Support Supplies	0,097	0,463	0,681	0,169	0,391	0,857	0,247	0,871	0,507
Casinos & Gaming	0,457	0,111	0,074	0,314	0,758	0,658	0,255	0,590	0,892
Commercial Printing Services	0,622	0,665	0,728	0,394	0,543	0,621	0,671	0,750	0,733
Commodity Chemicals	0,393	0,702	0,321	0,293	0,685	0,208	0,435	0,763	0,086
Communications & Networking	0,648	0,886	0,887	0,760	0,484	0,665	0,547	0,656	0,359
Computer & Electronics Retailers	0,693	0,839	0,936	0,855	0,860	0,671	0,693	0,845	0,465

Computer Hardware	0,476	0,739	0,362	0,363	0,485	0,223	0,976	0,859	0,410
Construction & Engineering	0,001	0,100	0,112	0,036	0,393	0,630	0,203	0,996	0,966
Construction Materials	0,318	0,172	0,357	0,978	0,129	0,165	0,998	0,603	0,468
Construction Supplies & Fixtures	0,847	0,130	0,080	0,995	0,088	0,494	0,813	0,106	0,274
Consumer Lending	0,384	0,122	0,373	0,181	0,164	0,151	0,078	0,337	0,263
Consumer Publishing	0,901	0,314	0,198	0,592	0,355	0,390	0,888	0,150	0,288
Corporate Financial Services	0,304	0,194	0,062	0,160	0,107	0,161	0,237	0,086	0,600
Courier, Postal, Air Freight & Land-based logistics	0,144	0,314	0,725	0,154	0,209	0,614	0,224	0,047	0,119
Department Stores	0,261	0,091	0,024	0,227	0,132	0,061	0,439	0,106	0,078
Discount Stores	0,159	0,159	0,159	0,166	0,166	0,368	0,117	0,117	0,458
Distillers & Wineries	0,377	0,116	0,283	0,435	0,245	0,314	0,483	0,183	0,206
Diversified Chemicals	no data								
Diversified Industrial Goods Wholesale	0,943	0,809	0,935	0,762	0,681	0,530	0,947	0,692	0,766
Diversified Investment Services	0,308	0,608	0,680	0,143	0,344	0,344	0,202	0,488	0,488
Drug Retailers	0,106	0,324	0,378	0,166	0,391	0,413	0,614	0,508	0,143
Electric Utilities	0,862	0,368	0,052	0,808	0,054	0,049	0,549	0,197	0,061
Electrical Components & Equipment	0,044	0,045	0,129	0,196	0,224	0,353	0,246	0,708	0,305
Electronic Equipment & Parts	0,176	0,365	0,626	0,292	0,416	0,793	0,221	0,627	0,445
Employment Services	0,250		0,208	0,639	0,588	0,546	0,660	0,861	
Entertainment Production	0,032	0,109	0,047	0,040	0,072	0,022	0,250	0,298	0,121
Environmental Services & Equipment	0,121	0,796	0,253	0,464	0,912	0,201	0,604	0,228	0,550
Financial & Commodity Market Operators & Services									
Financial Technology									
Fishing & Farming	0,373	0,323	0,117	0,494	0,360	0,071	0,575	0,289	0,043
Food Processing	0,165	0,464	0,273	0,165	0,405	0,128	0,756	0,169	0,130
Food Retail & Distribution	0,523	0,631	0,089	0,132	0,806	0,137	0,193	0,684	0,514
Footwear	0,114	0,233	0,147	0,119	0,187	0,103	0,054	0,045	0,093

Forest & Wood Products	0,496	0,309	0,432	0,426	0,417	0,471	0,392	0,619	0,949
Ground Freight & Logistics	0,749	0,254	0,882	0,217	0,311	0,651	0,076	0,711	0,883
Healthcare Facilities & Services	0,435	0,086	0,039	0,364	0,015	0,004	0,004	0,001	0,001
Heavy Electrical Equipment	0,644	0,096	0,160	0,355	0,032	0,041	0,468	0,216	0,357
Heavy Machinery & Vehicles	0,325	0,047	0,660	0,285	0,031	0,708	0,281	0,036	0,916
Highways & Rail Trucks	0,664	0,830	0,830	0,623	0,674	0,465	0,674	0,227	0,068
Home Furnishing	0,261	0,308	0,232	0,863	0,511	0,933	0,453	0,745	0,886
Home Furnishing Retailers	0,360	0,026	0,026	0,373	0,054	0,054	0,212	0,142	0,142
Home Improvement Products & Service Retail	0,306	0,546	0,989	0,661	0,895	0,903	0,685	0,277	0,277
Hotels, Motels & Cruise Lines	0,358	0,007	0,002	0,322	0,082	0,036	0,808	0,862	0,748
Household Electronics	0,280	0,457	0,602	0,263	0,478	0,549	0,800	0,552	0,632
Household Products	0,247	0,062	0,092	0,247	0,308	0,159		0,901	0,273
Independent Power Producers	0,021	0,109	0,484	0,027	0,087	0,336	0,165	0,850	0,801
Industrial Machinery & Equipment	0,005	0,313	0,373	0,020	0,510	0,172	0,257	0,172	0,539
Integrated Hardware & Software									
Integrated Telecommunication Services	0,680	0,105	0,439	0,427	0,232	0,501	0,652	0,400	0,767
Investment Banking & Brokerage Services	0,294	0,568	0,289	0,490	0,699	0,467	0,481	0,487	0,500
Investment Holding Companies	0,361	0,714	0,023	0,064	0,892	0,073	0,179	0,798	0,717
Investment Management & Fund Operators	0,338	0,596	0,818	0,779	0,973	0,889	0,560	0,418	0,439
Iron & Steel	0,072	0,045	0,133	0,129	0,043	0,268	0,083	0,045	0,096
IT Services & Consulting	0,178	0,915	0,824	0,613	0,907	0,864	0,158	0,456	0,924
Leisure & Recreation	0,729	0,997	0,801	0,917	0,883	0,888	0,794	0,836	0,452
Life & Health Insurance	0,228	0,530	0,773	0,957	0,991	0,944	0,652	0,447	0,479
Marine Freight Logistics	0,897	0,850	0,850	0,692	1,000	1,000	0,482	0,839	0,839
Marine Port Services	0,037	0,210	0,210	0,127	0,294	0,505	0,513	0,311	0,739
Medical Equipment, Supplies & Distribution	0,598	0,393	0,210	0,679	0,171	0,106	0,306	0,063	0,087
Mining Support Services & Equipment	0,923	0,183	0,187	0,584	0,308	0,246	0,055	0,137	0,454

Miscellaneous Specialty Retailers	0,983	0,794	0,333	0,644	0,728	0,624	0,627	0,881	0,465
Multiline Insurance & Brokers	0,148	0,844	0,844	0,165	0,686	0,686	0,051	0,215	0,728
Multiline Utilities	0,841	0,924	0,820	0,779	0,797	0,698	0,634	0,650	0,899
Natural Gas Utilities	0,500	0,243	0,522	0,289	0,288	0,402	0,273	0,317	0,643
Non-Alcoholic Beverages	0,174	0,460	0,365	0,041	0,323	0,778	0,029	0,102	0,718
Non-Gold Precious Metals & Minerals	0,885	0,586	0,461	0,111	0,211	0,705	0,109	0,326	0,545
Non-Paper Containers & Packaging	0,644	0,539	0,892	0,735	0,269	0,982	0,883	0,431	0,899
Office Equipment	0,798	0,243	0,711	0,308	0,261	0,641	0,962	0,718	0,803
Oil & Gas Refining and Marketing	0,283	0,755	0,642	0,395	0,871	0,636	0,191	0,265	0,915
Oil & Gas Transportation Services			0,159			0,165			0,159
Online Services	0,138	0,644	0,467	0,370	0,869	0,634	0,796	0,781	0,481
Paper Packaging	0,903	0,648	0,814	0,791	0,388	0,909	0,634	0,233	0,859
Paper Products	0,401	0,114	0,101	0,357	0,172	0,208	0,096	0,387	0,434
Passenger Transportation, Ground & Sea	0,161	0,740	0,736	0,227	0,917	0,383	0,018	0,232	0,650
Personal Products	0,143	0,084	0,040	0,086	0,118	0,004	0,094	0,128	0,321
Personal Services	0,316	0,350	0,662	0,246	0,371	0,621	0,076	0,314	0,834
Pharmaceuticals	0,013	0,382	0,782	0,437	0,691	0,663	0,320	0,107	0,095
Professional Information Services	0,324	0,615	0,615	0,377	0,861	0,861	0,806	0,806	0,806
Property & Casualty Insurance	0,111	0,374	0,219	0,111	0,325	0,243		0,111	0,204
Real Estate Rental, Developmennt & Operations	0,351	0,021	0,144	0,449	0,036	0,368	0,341	0,042	0,263
Real Estate Services	0,503	0,287	0,142	0,552	0,482	0,316	0,034	0,008	0,002
Recreational Products	0,764	0,735	0,206	0,193	0,493	0,333	0,317	0,363	0,401
Renewable Energy Equipment & Services		0,748	0,243		0,937	0,170		0,652	0,922
Restaurants & Bars	0,491	0,226	0,212	0,638	0,955	0,995	0,848	0,329	0,378
Semiconductors	0,998	0,358	0,445	0,894	0,057	0,157	0,698	0,068	0,250
Software	0,381	0,699	0,388	0,244	0,494	0,203	0,522	0,371	0,272
Specialty Chemicals	0,677	0,504	0,255	0,876	0,392	0,327	0,511	0,408	0,952

Specialty Mining & Metals	0,053	0,764	0,493	0,127	0,998	843,000	0,548	0,849	0,857
Textiles & Leather Goods	0,974	0,514	0,511	0,974	0,662	0,326	0,885	0,767	0,261
Tires & Rubber Products	1,000	0,862	0,777	0,739	0,597	0,693	0,800	0,359	0,610
Toys & Childrens Products	0,206	0,711	0,799	0,456	0,830	0,499	0,497	0,442	0,195
Water & Related Utilities	0,927	0,833	0,418	0,458	0,750	0,484	0,200	0,896	0,525
Values < 0,05	8	9	13	6	6	8	6	8	4
Relation < 0,05	7,8%	8,7%	12,4%	5,8%	5,8%	7,6%	5,9%	7,7%	3,8%
Values ≥ 0,05	95	94	92	97	98	97	95	96	100
Relation ≥ 0,05	92,2%	91,3%	87,6%	94,2%	94,2%	92,4%	94,1%	92,3%	96,2%
Total Values	103	103	105	103	104	105	101	104	104

10.4.1.4 Empirical results of ANOVA with respect to the Total Debt % of Total Assets

Industry	3 Year Average 5 km	15 km	25 km	5 Year Average 5 km	15 km	25 km	10 Year Average 5 km	15 km	25 km
Advanced Medical Equipment & Technology	0,682	0,580	0,321	0,412	0,262	0,393	0,476	0,584	0,545
Advertising & Marketing	0,914	0,475	0,501	0,852	0,668	0,832	0,426	0,262	0,292
Aerospace & Defense	0,331	0,329	0,329	0,339	0,347	0,347	0,566	0,625	0,625
Agricultural Chemicals	0,695	0,695	0,695	0,734	0,734	0,734	0,594	0,594	0,594
Airlines	0,849	0,958	0,933	0,559	0,283	0,442	0,717	0,717	0,555
Airport Operators & Services	0,127	0,127	0,127	0,127	0,127	0,127	0,127	0,127	0,127
Aluminum	0,317	0,404	0,541	0,282	0,370	0,723	0,205	0,426	0,681
Apparel & Accessories	0,313	0,048	0,320	0,126	0,485	0,164	0,126	0,345	0,112
Apparel & Accessories Retailers	0,274	0,409	0,208	0,270	0,815	0,066	0,648	0,662	0,287
Appliances, Tools & Houseware	0,531	0,237	0,876	0,483	0,188	0,631	0,611	0,178	0,736
Auto & Truck Manufacturers	0,425	0,135	0,020	0,242	0,031	0,002	0,652	0,021	0,004
Auto Vehicles, Parts & Service Retailers	0,064	0,308	0,545	0,023	0,178	0,724	0,049	0,070	0,670
Auto, Truck & Motorcycle Parts	0,870	0,554	0,029	0,891	0,687	0,396	0,584	0,987	0,617
Banks	0,456	0,273	0,278	0,416	0,186	0,187	0,301	0,108	0,108
Biotechnology & Medical Research	0,248	0,391	0,154	0,587	0,305	0,189	0,781	0,157	0,676
Brewers	0,770	0,770	0,606	0,117	0,117	0,732	0,157	0,157	0,157
Broadcasting	0,157	1,000	0,165	0,221	0,221	0,221	0,221	0,221	0,221
Business Support Services	0,023	0,025	0,024	0,183	0,079	0,045	0,065	0,052	0,121
Business Support Supplies	0,676	0,270	0,701	0,573	0,223	0,543	0,947	0,359	0,981
Casinos & Gaming	0,059	0,171	0,085	0,033	0,077	0,033	0,725	0,502	0,725
Commercial Printing Services	0,177	0,139	0,327	0,233	0,114	0,143	0,522	0,140	0,769
Commodity Chemicals	0,201	0,912	0,969	0,188	0,916	0,541	0,507	0,394	0,220
Communications & Networking	0,664	0,414	0,949		0,263	0,948		0,283	0,461
Computer & Electronics Retailers	0,862	0,735	0,195	0,343	0,441	0,241	0,699	0,273	0,318

Computer Hardware	0,524	0,400	0,677	0,616	0,423	0,603	0,772	0,444	0,453
Construction & Engineering	0,711	0,003	0,078	0,791	0,070	0,055	0,681	0,066	0,026
Construction Materials	0,405	0,552	0,586	0,275	0,526	0,583	0,253	0,404	0,950
Construction Supplies & Fixtures	0,903	0,501	0,725	0,713	0,678	0,625	0,535	0,525	0,866
Consumer Lending	0,204	0,082	0,226	0,078	0,052	0,270	0,106	0,268	0,391
Consumer Publishing	0,748	0,202	0,380	0,769	0,291	0,495	0,566	0,050	0,166
Corporate Financial Services	0,242	0,406	0,821	0,259	0,650	0,809	0,378	0,899	0,933
Courier, Postal, Air Freight & Land-based logistics	0,918	0,794	0,722	0,796	0,698	0,798	0,402	0,687	0,476
Department Stores	0,585	0,714	0,420	0,666	0,487	0,338	0,345	0,715	0,346
Discount Stores							0,143	0,143	0,143
Distillers & Wineries	0,901	0,860	0,968	0,793	0,989	0,807	0,657	0,890	0,884
Diversified Chemicals									
Diversified Industrial Goods Wholesale	0,387	0,206	0,154	0,654	0,574	0,212	0,536	0,334	0,129
Diversified Investment Services	0,643	0,746	0,746	0,714	0,549	0,549	0,444	0,341	0,341
Drug Retailers	0,221	0,149	0,084	0,414	0,406	0,049	0,734	0,790	0,034
Electric Utilities	0,676	0,270	0,701	0,573	0,223	0,543	0,947	0,359	0,981
Electrical Components & Equipment	0,385	0,698	0,756	0,267	0,808	0,923	0,197	0,199	0,127
Electronic Equipment & Parts	0,472	0,771	0,888	0,461	0,485	0,405	0,670	0,263	0,123
Employment Services	0,954	0,507	0,597	0,572	0,107	0,657	0,149	0,202	0,334
Entertainment Production	0,162	0,082	0,203	0,082	0,074	0,195	0,197	0,133	0,049
Environmental Services & Equipment	0,315	0,106	0,114	0,194	0,044	0,139	0,251	0,168	0,664
Financial & Commodity Market Operators & Services	0,311	0,683	0,683	0,325	0,726	0,726	0,417	0,724	0,724
Financial Technology	0,317	0,317	0,317	0,457	0,979	0,843	0,127	0,401	0,258
Fishing & Farming									
Food Processing	0,545	0,579	0,539	0,461	0,191	0,100	0,451	0,118	0,190
Food Retail & Distribution	0,241	0,016	0,019	0,057	0,019	0,180	0,421	0,379	0,803
Footwear	0,124	0,288	0,214	0,226	0,559	0,378	0,435	0,235	0,405

Forest & Wood Products	0,288	0,007	0,531	0,996	0,023	0,911	0,931	0,142	0,264
Ground Freight & Logistics	0,240	0,574	0,743	0,059	0,564	0,922	0,266	0,425	0,609
Healthcare Facilities & Services	0,024	0,043	0,566	0,033	0,060	0,395	0,072	0,158	0,301
Heavy Electrical Equipment	0,232	0,489	0,883	0,242	0,727	0,802	0,237	0,781	0,651
Heavy Machinery & Vehicles	0,704	0,514	0,569	0,955	0,676	0,695	0,881	0,606	0,601
Highways & Rail Trucks	0,480	0,576	0,366	0,390	0,468	0,227	0,283	0,414	0,304
Home Furnishing	0,292	0,369	0,414	0,428	0,235	0,187	0,143	0,284	0,298
Home Furnishing Retailers	0,086	0,039	0,028	0,090	0,086	0,066	1,000	0,474	0,295
Home Improvement Products & Service Retail	0,439	0,439	0,439	0,624	0,624	0,624	0,670	0,670	0,670
Hotels, Motels & Cruise Lines	0,279	0,151	0,389	0,223	0,043	0,243	0,176	0,089	0,329
Household Electronics	0,157	0,279	0,279	0,602	0,721	0,721	0,143	0,155	0,155
Household Products		0,245	0,331		0,513	0,394		0,513	0,394
Independent Power Producers	0,248	0,323	0,485	0,409	0,329	0,391	0,322	0,329	0,584
Industrial Machinery & Equipment	0,375	0,232	0,912	0,311	0,159	0,911	0,284	0,053	0,270
Integrated Hardware & Software									
Integrated Telecommunication Services	0,556	0,688	0,918	0,677	0,358	0,436	0,719	0,243	0,116
Investment Banking & Brokerage Services	0,627	0,571	0,627	0,436	0,450	0,436	0,475	0,670	0,475
Investment Holding Companies	0,250	0,587	0,137	0,202	0,735	0,189	0,015	0,721	0,218
Investment Management & Fund Operators	0,051	0,107	0,088	0,187	0,182	0,291	0,483	0,080	0,268
Iron & Steel	0,166	0,958	0,795	0,457	0,989	0,606	0,208	0,680	0,247
IT Services & Consulting	0,643	0,102	0,393	0,731	0,531	0,591	0,695	0,161	0,868
Leisure & Recreation	0,284	0,472	0,929	0,131	0,672	0,743	0,666	0,755	0,555
Life & Health Insurance	0,855	0,708	0,596	0,555	0,228	0,209	0,351	0,546	0,132
Marine Freight Logistics	0,571	0,571	0,571	0,394	0,394	0,394	0,591	0,391	0,391
Marine Port Services		0,513	0,513		0,513	0,513		0,699	0,699
Medical Equipment, Supplies & Distribution	0,391	0,412	0,262	0,488	0,380	0,215	0,171	0,129	0,459
Mining Support Services & Equipment	0,535	0,572	0,572	0,487	0,514	0,347	0,159	0,628	0,486

Miscellaneous Specialty Retailers	0,808	0,836	0,183	0,988	0,860	0,407	0,886	0,396	0,130
Multiline Insurance & Brokers	0,448	0,498	0,498	0,352	0,195	0,195	0,526	0,300	0,300
Multiline Utilities	0,281	0,850	0,286	0,341	0,481	0,889	0,289	0,359	0,954
Natural Gas Utilities	0,181	0,114	0,043	0,172	0,100	0,073	0,247	0,126	0,083
Non-Alcoholic Beverages	0,504	0,517	0,571	0,592	0,569	0,322	0,639	0,965	0,537
Non-Gold Precious Metals & Minerals	0,469	0,442	0,315		0,350	0,424		0,296	0,431
Non-Paper Containers & Packaging	0,388	0,645	0,319	0,285	0,496	0,458	0,510	0,501	0,377
Office Equipment	0,450	0,808	0,678	0,594	0,572	0,494	0,823	0,166	0,211
Oil & Gas Refining and Marketing	0,361	0,361	0,194	0,632	0,632	0,354	0,165	0,219	0,149
Oil & Gas Transportation Services	0,388	0,645	0,319	0,285	0,496	0,458	0,510	0,501	0,377
Online Services	0,284	0,470	0,222	0,723	0,648	0,905	0,585	0,609	0,612
Paper Packaging	0,361	0,361	0,194	0,632	0,632	0,354	0,165	0,219	0,149
Paper Products	0,833	0,423	0,161	0,774	0,236	0,058	0,935	0,671	0,309
Passenger Transportation, Ground & Sea	0,455	0,784	0,185	0,781	0,653	0,130	0,999	0,694	0,199
Personal Products	0,502	0,467	0,192	0,220	0,189	0,120	0,103	0,078	0,188
Personal Services	0,123	0,617	0,908	0,190	0,517	0,694	0,135	0,309	0,152
Pharmaceuticals	0,759	0,180	0,256	0,781	0,158	0,383	0,395	0,052	0,187
Professional Information Services	0,157	0,157	0,344	0,168	0,168	0,300	0,168	0,168	0,300
Property & Casualty Insurance		0,317			0,221	1,000			0,317
Real Estate Rental, Developmennt & Operations	0,633	0,252	0,729	0,796	0,405	0,738	0,662	0,786	0,625
Real Estate Services	0,878	0,048	0,276	0,732	0,066	0,065	0,499	0,230	0,798
Recreational Products	0,630	0,139	0,460	0,414	0,180	0,166	0,385	0,273	0,243
Renewable Energy Equipment & Services		0,317	0,463		0,264	0,580		0,276	0,470
Restaurants & Bars	0,407	0,446	0,171	0,368	0,392	0,480	0,286	0,823	0,398
Semiconductors	0,199	0,301	0,390	0,331	0,205	0,344	0,523	0,252	0,269
Software	0,869	0,694	0,202	0,762	0,700	0,303	0,091	0,512	0,042
Specialty Chemicals	0,380	0,403	0,295	0,415	0,321	0,559	0,457	0,460	0,833

Specialty Mining & Metals	0,027	0,326	0,280	0,105	0,592	0,240	0,186	0,788	0,384
Textiles & Leather Goods	0,497	0,505	0,498	0,475	0,590	0,492	0,250	0,691	0,594
Tires & Rubber Products	1,000	0,159	0,601	0,795	0,223	0,465	0,450	0,150	0,751
Toys & Childrens Products	0,283	0,273	0,319	0,324	0,317	0,402	0,519	0,564	0,699
Water & Related Utilities	0,401	0,646	0,844	0,416	0,904	0,922	0,467	0,982	0,617
Values < 0,05	3	8	6	3	5	4	2	1	5
Relation < 0,05	2,9%	7,5%	5,7%	3,0%	4,7%	3,8%	2,0%	0,9%	4,7%
Values ≥ 0,05	99	98	99	97	101	102	99	105	102
Relation ≥ 0,05	97,1%	92,5%	94,3%	97,0%	95,3%	96,2%	98,0%	99,1%	95,3%
Total Values	102	106	105	100	106	106	101	106	107