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STRATEGIC FACTOR ANALYSIS FOR INDUSTRY 4.0

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Abstract. In impending decades Industrie 4.0 will challenge us in how to re-invent jobs in a world where machines will take our jobs. Although plenty of research has been carried out on the strategic importance of resources, capabilities, and boundaries where knowledge must be shared and assessed, no studies have been found which looking on strategic factor analysis for understanding how prepared we are for the fourth industrial revolution. Therefore asking the central research question "Is our strategy ready for the fourth industrial revolution?" Comparing the strategically related general and significant categories and subcategories of Industrie 4.0, with the strategic factor analysis summary themes and most important subcategories from firms in Estonia (n = 123), allowed answering the central research question that our strategy is only partly ready for the fourth industrial revolution. But the results of this study indicate also that we are ready in employee development, values, flexible services and products, high quality target, customer orientation, and strategy. Proposed solutions to overcome low profitability, lack of qualified manpower, and growth, could be expanding the market share into new markets, and development of innovative services. In order to be prepared for the fourth industrial revolution the development of a strategic knowledge vision is needed.

Keywords: capabilities, case study, Industrie 4.0, knowledge, skills, strategy, text analytics

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1. Introduction

The first sequence of industrial revolutions took place already in the 18th century, when the first industrial revolution was about the transition from hand production job shops to steam engine powered machinery enabling mass production. The second industrial revolution took place in the early 20th century, during which manufacturing was supercharged by electrification and the production lines. The third industrial revolution started in the late 20th century with the introduction of IT and digital revolution. In impending decades Industrie 4.0 will

challenge us in how to re-invent jobs in a world where machines will take our jobs. Work will be less centralized, more fluid, more projects oriented, and more virtual and international (SAP 2013). Decisions and actions that determine the long-run performance of a corporation is strategic management and its goal should be creating and capturing values (Wahl 2015). In the process of strategic management, the interrelated activities of internal and external environment scanning, strategy formulation, implementation, and evaluation result in a set of strategies. It can be stated that resources are always means, competencies powers, and capabilities abilities (Wahl & Prause, 2013), in the 'knowledge society', the basic economic resource is no longer capital, natural resources or labour but is, and will be, knowledge (Drucker 1993). Successful firms also harness a wider skills base, with proficient owners, leaders and managers whose expertise combines both commercial and technical acumen, typically in science, technology, engineering or mathematics (Foresight 2013). Although plenty of research has been carried out on the strategic importance of resources (Barney 1991; Grant 1991; Grant 1996; Kogut & Zander 1992), capabilities (Teece, Pisano, Shuen 1997; Augier, Teece 2009), and boundaries where knowledge must be shared and assessed (Carlile 2002; Carlile 2004; Wahl 2015; Tvaronavičienė, Černevičiūtė 2015), no studies have been found which looking on strategic factor analysis for understanding how prepared we are for the fourth industrial revolution. Therefore the author is asking in the central research question (CRQ): "Is our strategy ready for the fourth industrial revolution?" and asking three related research questions. RQ 1: "What are the general and significant categories and subcategories of the most important strategic factors?" RQ 2: "What are the general and significant categories and subcategories of Industrie 4.0?" RQ 3: "Are the most important strategic factors and Industrie 4.0 categories aligned?" The main purpose of this paper is to develop a better understanding for future and generating discussion and debate in this important research area.

The present paper is organised as follows. Section 2, "Theoretical framework: Strategies for Industrie 4.0" begins by defining the key categories that underscore the strategic management and Industrie 4.0 from a holistic perspective. Relevant theories and evidence relating to the categories are reviewed. Section 3, "Results and discussion: How prepared we are for the fourth industrial revolution" tells us about the used techniques and procedures of material and data collection into a case database and content analysis. Technical findings, results, interpretative analysis of meaningful relationships are explained. Conclude by describing the main insights and locating potential for the further research.

2. Theoretical framework: Strategies for Industrie 4.0

Here reviewing the state of the art relevant to the research questions, and presenting the major ideas in the field of Industrie 4.0. Contingency and unpredictability belong to the essence of our time - philosophy and future research show how we can profit precisely from that (Gransche 2015). The resource-based view (Barney 1991; Barney 2001) argues that valuable and rare resources can lead to the creation of competitive advantage that can be sustained over longer time periods. Accordingly, to the potential resources of a particular firm he allocates all assets, capabilities, organisational processes, firm attributes, information, knowledge etc. Adherents of the resource-based view generally agree that the most strategically important resource is knowledge (Osterloh & Frey 2000; Tvaronavičienė 2014).

The knowledge-based theory (Kogut & Zander 1992) of the firm considers knowledge as the most strategically significant resource of the firm; it is an outgrowth of resource-based view of the firm. Its proponents argue that because knowledge-based resources are usually difficult to imitate and socially complex, heterogeneous knowledge bases and capabilities among firms are the major determinants of sustained competitive advantage and superior corporate performance. This knowledge is embedded and carried through multiple entities including organizational culture and identity, policies, routines, documents, systems, and employees. While most explicit knowledge and all tacit knowledge are stored within individuals, much of this knowledge is created within the firm and is firm specific, this "organizational knowledge" is created through the interactions of individuals (Grant 1996). Both resource-based and capabilities research uses routines and resources as the units of analysis. Routines are defined as behaviour that is learned, highly patterned, repetitious or quasi-repetitious, founded in part in tacit knowledge (Winter 2003). Capabilities refer to a firm's capacity to deploy resources by incorporating organisational processes and are generated by a firm to provide enhanced productivity of its

resources as well as a strategic flexibility and protection for its final product or service (Amit & Schoemaker 1993). The ability to sense and then seize new opportunities, and to reconfigure and protect knowledge assets, competencies, and complementary assets is dynamic capability (Augier & Teece 2009), achieving a sustained competitive advantage needs dynamic capabilities. Dynamic capabilities research emphasizes the importance of knowledge assets and learning for understanding firm performance differences (Zollo & Winter 2002).

However, instead of seeing the firm as a bundle of resources (Barney 1991), it can be more completely described as a bundle of different types of boundaries where knowledge must be shared and assessed (Carlile 2004). It starts at the origin where the differences and dependencies are known; as novelty increases the vector spreads, scaling the increasing complexity and the amount of effort required to manage the boundary. Moving up in complexity, the process or capacity at a more complex boundary still requires the capacities of those below it. Transferring is the way of crossing a syntactic boundary creating common language using taxonomies, storage and retrieval technologies. The transferability of a firm's resources and capabilities are a critical determinant of their capacity to confer sustainable competitive advantage, with regard to knowledge, the issue of transferability is important, not only between firms, but even more critically, within the firm (Grant 1996). A syntactic capacity requires the development of a common lexicon (e.g. databases or common technical terms) for transferring domain specific knowledge. The Knowledge transfer process depends on individual factors (skills and expertise), organisational factors (structure and policy) and technological factors (available IT systems) which results in innovation capability. Actors' proficiency is a high degree of skill and expertise, skill is the ability to do something well, where expertise is expert skill or knowledge in a particular field (Oxford dictionary of English 2010). Lack of adequate skill-sets is seen as a challenge, another is to develop employee skills in a targeted manner (Wagner 2015). Craftsman like skills as well as corporate cultures probably develop and transfer largely through tacit communication (Hedlund 1994). Modern information and communication technologies will help to increase productivity, quality and future flexibility (Ganschar, Gerlach, Hämmerle, Krause & Schlund 2013). When managers create a work environment that allows peers to understand craftsmanship and expertise through practice and demonstrations by a master, transfer of tacit knowledge takes place (Nonaka, Toyama, & Konno 2000). Among all the other factors that influencing knowledge transfer in order to cross syntactic boundaries, the absorptive capacity of the receiving units stands out as the most significant determinant of knowledge transfer (Gupta & Govindarajan 2000). Absorptive capacity is defined as "the ability to recognize the value of new external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal 1990, p. 128). Management experience significantly stimulates start-up absorptive capacity within highly dynamic environments, whereas it hinders it within stable environments (Debrulle, Maes, & Sels 2014). Translating is the way of crossing a semantic boundary, creating shared meanings in community of practice or cross functional teams using boundary spanners or translators. A semantic capacity develops common meanings for identifying novel differences and dependencies and translating domain specific knowledge. Transforming is the way of crossing a pragmatic boundary creating common interests to share and assess knowledge, using prototyping and other kinds of boundary object. A pragmatic capacity establishes common interests for making trade-offs and transforming domain-specific knowledge. When different interests arise, developing an adequate common knowledge is a political process of negotiating interests, making trade-offs between actors, and defining common interests (Carlile 2004).

While new product and service creation is an essential task to ensure a firm's immediate success in the marketplace, process and supply chain innovations can also create a unique source of competitive advantage for the future (Carrillo, Druehl, & Hsuan 2015). Industrie 4.0 calls the next wave of industrialization through the use of internet of things, internet of services, and cyber physical systems. The real world is turning into a huge information system (Dujin, Geissler, & Horstkötter 2014). One possible definition for Industrie 4.0 proposed: "It is a collective term for technologies and concepts of value chain organization" (Hermann, Pentek, & Otto 2015, p. 11), a new way of producing and consuming, integrating design, manufacturing and servicing. Successful firms will be capable of rapidly adapting their physical and intellectual infrastructures to exploit changes in technology as manufacturing becomes faster, more responsive to changing global markets and closer to customers. Customer orientation is becoming increasingly important; one major tendency showing a pronounced customer orientation and clear focus on customer benefit is to involve customers directly in development (Wagner 2015).

Future threats and or opportunities are related to the output (personalized, local production and mass customization), process (networked manufacturing and cluster dynamics, end-to-end digital engineering, top floor-shop floor integration, real-time and value-added networks), business models (fragmentation of the value chain, integrated service offerings, creation and development of emotional products and services, modular architecture and customer co-creation), competition (converging frontiers), globalization (light footprint, low-cost and frugal innovation), skills (interdisciplinary thinking is key, higher degree of complexity), (Dujin, Geissler, & Horstkötter 2014; SAP 2013; Wagner 2015).

As mentioned in the literature review, the general and significant categories and subcategories of Industrie 4.0 are strategically related to vision, mission, values, norms, competition, knowledge, business models, skills, capabilities, actions, behaviour, processes, routines, context, globalization, results, output, performance and management, governance, learning.

3. Results and discussion: How prepared we are for the fourth industrial revolution

For answering all proposed research questions the chosen research strategy is case study, using mixed methods, and it can be categorised as an explanatory, cross-sectional research project. Case study strategy is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially because the boundaries between phenomenon and context are not clearly evident (Yin 2009). Case studies provide a rich understanding of a real life context, using and triangulate multiple sources of data.

Every chosen case were starting with a careful study of the firm, using a strategic audit worksheet. Next step included doing outside research, calculating common size financial statements, and key ratios, if appropriate. Here also describing the basic corporate governance mechanisms of the corporation. Owners and managers are the people who are primarily tasked with the strategic management process if the corporation is to have long-term success in accomplishing its mission. The advanced analysis started with the external (EFAS), and internal (IFAS) factor analysis, concluding in a comprehensive strategic factor analysis summary (SFAS). All 2014 collected material and data from firms in Estonia, is entered into a MS Excel case database. All chosen firms, cases (n = 123) are thoroughly described and coded. Data is checked for errors, cleaned, pre-processed. Thematic case analysis and case contrasts were done before analysis of empirical regularities.

For computer analysis Microsoft Excel and Leximancer were used. Text is more than a collection of words, it tells a story. Ideas, concepts, and relationships are buried in the words. Leximancer is text mining software that can be used for content analysis of collections of textual documents and to visually display the extracted information. The information is displayed by means of a conceptual map that provides an overview of the material, representing the main concepts contained within the text and how they are related. It analyses automatically texts to identify the high level concepts, delivering the key ideas and actionable insights needed with powerful interactive visualisations and data exports. Helping to understand of what text is really saying. (Leximancer 2014) The Leximancer is transforming lexical co-occurrence information from natural language into semantic patterns in an unsupervised manner. It employs two stages of co-occurrence information extraction – semantic and relational, using a different algorithm for each stage. The algorithms used are statistical but they employ nonlinear dynamics and machine learning. (Smith & Humphreys 2006) Leximancer enables to navigate the complexity of text in a uniquely automated fashion, it identifies ‘Concepts’ within the text – not merely keywords but focused clusters of related, defining terms as conceptualised by the author.

Themes are circles that group clusters of concepts. Internal factors, strengths are divided in three themes; they are market, range, and experience. The thematic summary includes a ‘connectivity’ score to indicate the relative importance of the themes. Connectivity scores for market (100%), range (52%), and experience (32%). Employee development, organisational culture and values, leadership, being the leader in the market, broad variety of services and products, high quality, customer orientation, long term planning and strategy are the most important subcategories. The Concepts are presented in a compelling, interactive display so that it is possible to visualise and interrogate their inter-connectedness and co-occurrence, this is as important as the concepts themselves. The insight dashboard

report is a useful way of encapsulating the quantitative correlations between selected dependent segments and the observed text concepts, along with the supporting textual evidence for better understanding. (Leximancer 2014) Internal factors, weaknesses are divided in four themes; they are lack, turnover, growth, and group.

The most important theme is 'lack', and less important themes are 'turnover', 'growth', and 'group'. Connectivity scores are shown for lack (100%), turnover (16%), growth (6%) and group (2%). Low profitability, capacity of the management, drawbacks in technology and marketing strategy, lack of qualified manpower, slacken growth of tempo, lack of International Networking, labour turnover, tight target group for services and products are the most important subcategories.

External factors, opportunities are divided in six themes; they are market, foreign, real estate, Asia, economic, and service. The most important theme is 'market', and less important are 'foreign', 'real estate', 'Asia', 'economic' and 'service'. Connectivity scores are shown for market (100%), foreign (30%), real estate (14%), Asia (4%), economic (2%) and service (1%). Expanding the market share into new markets starting with Baltic Countries and Finland, the growth of demand, activating the real estate market, and the development of services are the most important subcategories.

External factors, threats are divided in six themes; they are price, materials, economic, service, competition, and market. The most important theme is 'price', and less important themes are 'materials', 'economic', 'service', 'competition' and 'market'. Connectivity scores are shown for price (100%), materials (68%), economic (13%), service (4%), competition (3%), and market (2%). Tight competition, toughen laws and regulations, the growth of raw material's prices and quality pressure are the most important subcategories. The examined categories and subcategories of the most important strategic factors should be not only described but also "understood" and "explained", therefore the meaningful relationships that form the basis of the empirically founded themes were analysed.

Comparing the strategically related general and significant categories and subcategories of Industrie 4.0 (vision, mission, values, boundaries, competition, knowledge, business models, skills, capabilities, actions, behaviour, processes, routines, context, globalization, results, output, performance and management, governance, learning), with the most important SFAS themes (economic, experience, foreign, growth, lack, market, materials, price, range, real estate, and turnover) and most important subcategories, allowed answering the central research question that our strategy is only partly ready for the fourth industrial revolution.

These results are in accord with recent study "Roland Berger Industry 4.0 readiness index" for the EU's key industrial countries, indicating that Estonia belongs to the cluster called "Hesitators", lacks a reliable industrial base and suffering from severe fiscal problems and is therefore not able to make economy future-proof (Dujin, Geissler, & Horstkötter, 2014). The results of this study indicate also that our strategy is ready for the fourth industrial revolution in employee development, values, flexible services and products, high quality target, customer orientation, and strategy. Unfortunately struggling with low profitability, lack of qualified manpower, and slacken growth of tempo. Proposed solutions could be expanding the market share into new markets, and development of innovative services.

4. Conclusions

The central research question „Is our strategy ready for the fourth industrial revolution?" set by the author has been answered. The main purpose to develop a better understanding for future and generating discussion and debate in this important area reached. Interpreting the results, it is important to keep in mind that the case database consists only few competitive case studies (n = 123). It is recommended that further research should include general systems theory, which is not explicitly used as a theoretical framework in strategic management. Methodologically the research is valuable used modern text analytics for an innovative way to present, and to garner deeper insight from texts. Practically, in order to be prepared for the fourth industrial revolution the development of a strategic knowledge vision is needed.

References

Amit, R.; Schoemaker, P. 1993. Strategic assets and organisational rent. *Strategic Management Journal* 14: 33–46.

Augier, M.; Teece, D. J. 2009. Dynamic capabilities and the role of managers. *Organization Science* 20(2): 410–421.

Barney, J. B. 1991. Firm resources and sustained competitive advantage. *Journal of Management* 17(1): 99–120.

Barney, J. B. 2001. Is the resource-based "view" a useful perspective for strategic management research? Yes. *Academy of Management Review* 26(1): 41–56.

Carlile, P. R. 2002. A pragmatic view of knowledge and boundaries. *Organization Science* 13(4): 442–455.

Carlile, P. R. 2004. Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science* 15(5): 555–568.

Carrillo, J. E.; Druehl, C.; Hsuan, J. 2015. Introduction to innovation within and across borders: A review and future directions. *Decision Sciences* 46: 225–265.

Cohen, W.; Levinthal, D. 1990. Absorptive capacity: A new perspective on learning and innovation. *Administration Science Quarterly* 35(1): 128–152.

Debrulle, J.; Maes, J.; Sels, L. 2014. Start-up absorptive capacity: Does the owner's human and social capital matter? *International Small Business Journal* 32(7): 777–801.

Drucker, P. F. 1993. *Post-capitalist society.* Oxford: Butterworth. 232 p.

Dujin, A.; Geissler, C.; Horstkötter, D. (Eds.). 2014. *Industry 4.0: The new industrial revolution.* Munich: Roland Berger Strategy Consultants GmbH. 24 p.

Foresight. 2013. *The future of manufacturing: A new era of opportunity and challenge for the UK.* London: The Government Office for Science. 54 p.

Ganschar, O.; Gerlach, S.; Hämmerle, M.; Krause, T.; Schlund, S. 2013. *Produktionsarbeit der Zukunft: Industrie 4.0.* (D. Spath, Hrsg.) Stuttgart: Fraunhofer Verlag. 155 p.

Gransche, B. 2015. *Vorausschauendes Denken: Philosophie und Zukunftsforschung jenseits von Statistik und Kalkül.* Bielefeld: transcript Verlag. 456 p.

Grant, R. M. 1991. The resource-based theory of competitive advantage: Implications for strategy formulation. *California Management Review* 33(3): 114–135.

Grant, R. M. 1996. Toward a knowledge-based theory of the firm, *Strategic Management Journal* 17(S2): 109–122.

Gupta, A. K.; Govindarajan, V. 2000. Knowledge flows within multinational corporations, *Strategic management journal* 21(4): 473–496.

Hedlund, G. 1994. A model of knowledge management and the N-form Corporation, *Strategic Management Journal* 15(S2): 73–90.

Hermann, M.; Pentek, T.; Otto, B. 2015. *Design principles for Industrie 4.0 scenarios: A literature review.* Fakultät Maschinenbau, Audi Stiftungslehrstuhl Supply Net Order Management. Dortmund: Technische Universität Dortmund. 15 p.

Kogut, B.; Zander, U. 1992. Knowledge of the firm, combinative capabilities and the replication of technology, *Organization Studies* 3(3): 383–397.

Leximancer. 2014, July 20. Retrieved from http://info.leximancer.com

Nonaka, I.; Toyama, R.; Konno, N. 2000. SECI, Ba and Leadership: A unified model of dynamic knowledge creation, *Long Range Planning* 33(1): 5–34.

Osterloh, M.; Frey, B. S. 2000. Motivation, knowledge transfer, and organizational forms, *Organization Science* 11(5): 538–550.

Oxford dictionary of English. 2010. *Oxford dictionary of English* (3rd ed.). (A. Stevenson, Ed.) Oxford, UK: Oxford University Press. 2069 p.

SAP. 2013. *Production of the future: How to prepare for the fourth industrial revolution.* Walldorf: SAP. 72 p.

Smith, A. E.; Humphreys, M. S. 2006. Evaluation of unsupervised semantic mapping of natural language with Leximancer concept mapping. *Behavior Research Methods* 38(2): 262–279.

Zollo, M.; Winter, S. G. 2002. Deliberate learning and the evolution of dynamic capabilities, *Organization Science* 13(3): 339–351.

Teece, D. J.; Pisano, G.; Shuen, A. 1997. Dynamic capabilities and strategic management, *Strategic Management Journal* 18(7): 509–533.

Tvaronavičienė, M. 2014. If industrial sector development is sustainable: Lithuania compared to the EU, *Entrepreneurship and Sustainability Issues* 1(3):134–142. DOI: http://dx.doi.org/10.9770/jesi.2014.1.3(2)

Tvaronavičienė, M.; Černevičiūtė, J. 2015. Technology transfer phenomenon and its impact on sustainable development, *Journal of Security and Sustainability Issues* 5(1): 87–97. DOI: http://dx.doi.org/10.9770/jssi.2015.5.1(7)

Wagner, F. (Hrsg.). 2015. *FuE - Fit für die Zukunf: Trends und Erfolgsfaktoren in der Forschung und Entwicklung.* Stuttgart: Fraunhofer Verlag. 80 p.

Wahl, M. F. 2015. Strategic audit and ownership strategy, *International Journal of Business and Social Research* 5(9): 93–100.

Wahl, M. F.; Prause, G. 2013. Toward understanding resources, competencies, and capabilities: Business model generation approach, *Journal of Entrepreneurship and Sustainability Issues* 1(2): 67–80. DOI: http://dx.doi.org/10.9770/jesi.2013.1.2(1)

Winter, S. G. 2003. Understanding dynamic capabilities, *Strategic Management Journal* 24(10): 991–995.

Yin, R. K. 2009. *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage. 219 p.