Introducing the Internet of Things in the German manufacturing industry

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Abstract

This paper investigates the introduction of the Internet of Things in the German manufacturing industry. Large changes for one of the most industrialized countries worldwide with a huge manufacturing industry are expected. There applicable strategies have to be developed resembling upcoming challenges, also investigating digital conversions in manufacturing operations.

Keywords: Industrial Internet of Things, Small and medium-sized enterprises, Digitalization

INTRODUCTION

Industrial Internet of Things

The Internet of Things is a largely discussed topic in literature and practical application (Lee 2015).

The concept of Internet of Things intends to establish an intelligent, self-regulatory and internet-based interconnection of humans, machines, products, and services along the entire value-added chain. For its application within industry, the concept of the Industrial Internet of Things was created (Kagermann et al. 2013). The concept of the Industrial Internet of Things is developed in several different programs aiming at its regional scope, e.g. 'Industry 4.0' in Germany (Kagermann et al. 2013), 'Advanced manufacturing partnership (AMP)' in the USA (Advanced Manufacturing National Program Office 2013) or 'Made in China 2025' in China (Lee 2015). Germany aims to further establish its market leader in engineering (Kagermann et al. 2013), whereas the USA attempt for a re-industrialization (Advanced Manufacturing National Program Office 2013) and China for augmented productivity (Lee 2015). Germany it is one of the most industrialized countries in the western world, therefore resembling high validity for Europe and the USA (OECD 2013).

The implementation of the Industrial Internet of Things inflicts numerous challenges within value-added chains. The benefits in industry are expected to be numerous. Reaidy et al. (2014) expect warehousing potentials connected to the Internet of Things, whereas Zhou et al. (2015) investigate logistics within the Internet of Things. Business models are expected to be established by the Internet of Things (Dijkman et al. 2015).

However, manufacturing enterprises that are affected by the Industrial Internet of Things are primarily not researched so far by academic investigations. Solely Yoona et al. (2012) describe the concept of ubiquitous factories. Especially, as large enterprises are affected as well as small enterprises (Kagermann et al. 2013), current investigations are solely focused on larger enterprises This topic has not been investigated yet in depth and breadth. Consequently, this paper investigates the Industrial Internet of Things in context of small and medium sized-enterprises, also in comparison to larger enterprises.

Small and medium-sized enterprises

For Small and medium-sized enterprises, two definitions are used frequently in Europe respectively Germany. The European Union (2003) defines Small and medium-sized enterprises as enterprises with less than 250 employees and an annual turnover below 50 million Euros. The German institute for Small and medium-sized enterprise research defines Small and medium-sized enterprises as enterprises that exceed both a number of 500 employees and an annual turnover of 50 million Euros (Günterberg and Wolter, 2002). For our investigation, the classification of Günterberg and Wolter (2002) is used as it includes the definition from the European Union (2003).

For Germany, Small and medium-sized enterprises play a major role, including 99.6 per cent of enterprises, 84.2 per cent of trained apprentices and 59.4 of employees. 54.8 per cent of value added and 35.9 per cent of turnover within is generated by Small and medium-sized enterprises- have increased importance in the three main branches within the manufacturing industry: mechanical engineering industry, electrical industry and automotive industry (German federal office for statistics 2015).

State of research

So far, no specific investigations exist for the introduction of the Industrial Internet of Things in Small and medium-sized enterprises exist. Concerning the adoption of new technologies, Small and medium-sized enterprises have been shown to have different approaches than larger enterprises (Zheng et al. 2004), therefore requiring different approaches in the context of technology adoption. Furthermore, innovation in Small and medium-sized enterprises depends on CEO innovation orientation more than in larger enterprises (Kraiczy et al. 2014).

Also, funding of new technology can be a limiting factor within Small and medium-sized enterprises (Revest and Sapio 2012). Therefore, information technology requires a different path for Small and medium-sized enterprises (Nguyen et al. 2015). Zheng et al. (2004) prove that especially Small and medium-sized enterprises show different characteristics in comparison to larger enterprises when introducing new technologies, applying a more cautious approach and deriving cost benefits differently.

Sadowski et al. (2002) investigate internet usage to be different within Small and medium-sized enterprises, it was often connected to producing actual benefits rather than competitive pressure for implementation. Bruque and Moyano (2007) describe that a firm's hierarchy and lacking access to expertise and qualified personnel can prevent application.

De Búrca et al. (2005) investigate on technology adoption for enterprise resource planning systems in Small and medium-sized enterprises, revealing a more cautious and awaiting approach in Small and medium-sized enterprises than in larger enterprises. These findings are supported by Buonanno et al. (2005). Pieri and Zaninotto (2013) show that vertical integration for Small and medium-sized enterprises has different efficiency factors than for larger enterprises. Rochina-Barrachina et al. (2010) and Hervas-Oliver et al. (2014) discuss the importance of process innovation for productivity and performance effects in Small and medium-sized enterprises.

METHODOLOGY

Currently, no research foundation to build upon exists. Therefore, an explorative and qualitative research method was chosen to develop a theoretical and well-proven framework. Qualitative approaches are meaningful when no underlying foundations are present and require the forming of an own framework for research (Holsti 1968).

To postulate similarities across all interview partners, a homogeneous sampling strategy was chosen, including enterprises from the three main branches of the German industry, mechanical engineering, electrical engineering and automotive suppliers (Curtis et al. 2000). An interview guideline was developed beforehand (Bryman and Bell 2007).

The interview guide was to keep the interview focused while allowing individual aspects and opinions to emerge (Gordon 1980). Following the data gathering, the interviews were recorded, transcribed and analyzed.

The sample of experts consists of the leading staff within 177 German manufacturing enterprises, including 103 Chief Executive Officers. This approach follows the ambition to obtain multiple sources of data, which enables qualitative research to increase validity and reliability (Maxwell 1996). Therefore, the obtained amount of interview partners can present as many insights as possible and postulate gathered data from different sources (Patton 2002).

RESULTS

The obtained results can be divided in challenges that regarded enterprises face for the introduction of the Industrial Internet of Things and corresponding possible solutions. Hereby, categories were formed that include the majority of answers as well as corresponding possible solutions. An overview of the obtained results can be observed in the following table.

Table 1 – Overview of obtained results

Challenges when introducing the Industrial Internet of Things	**Possible solutions named by interview partners**	**Predominant within smaller enterprises**
High costs	Cooperative approaches Outsourcing of capital commitment	X
Required level of expertise	Cooperative approaches Services by providers of technology	X
Creating interfaces	Predefinition of interfaces Cooperative approaches	
No unified standards	Predefinition of standards Regulatory standards by institutions	
Late amortization	Cooperative approaches Outsourcing of capital commitment	
No concise understanding	Information provision by institutions	X

CONCLUSION

This paper presents valuable insights for academia as well as practical application of the Industrial Internet of Things in the manufacturing industry, especially deriving differences between small

and larger enterprises. Currently unseen results for industrial enterprises can be derived. Due to the high importance of the Industrial Internet of Things for future industry, our research presents valuable and highly relevant insights for preparations that these enterprises have to perform to introduce the Industrial Internet of Things.

Furthermore, the results obtained by this paper can be a foundation for policy makers and institutions in order to integrate the Industrial Internet of Things in Germany as well as in the western world in order to obtain the expected results of preserving or even expanding competitiveness of industrial value creation.

However, this paper only represents the first step of an in depth investigation with multiple forms of investigation, attempting to integrate the Industrial Internet of Things in a theoretical framework of technology adaption in enterprises. Therefore, further investigations, also based on quantitative approaches in order to validate the qualitative framework, have to be conducted and are therefore currently undergone to expand the findings of this paper.

Bibliography

Advanced Manufacturing National Program Office. 2013. *Draft Institute Performance Metrics for the National Network for Manufacturing Innovation.* Available at: http://www.manufacturing.gov/docs/nnmi_draft_performance.pdf. (accessed date January 7, 2015)

Buonanno G., P. Faverio, F. Pigni, A. Ravarini, D. Sciuto, M. Tagliavini. 2005. *Factors affecting ERP system adoption: A comparative analysis between SMEs and large companies*. Journal of Enterprise Information Management **18**(4): 384-426

Bruque S., J. Moyano. 2007. *Organisational determinants of information technology adoption and implementation in SMEs: The case of family and cooperative firms*. Technovation **27**(5): 241-253

Bryman A., E. Bell. 2015. *Business Research Methods.* Oxford University Press, New York

Commission of the European Communities. 2003. *COMMISSION RECOMMENDATION of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises*

De Búrca S., B. Fynes, D. Marshall. 2005. *Strategic technology adoption: extending ERP across the supply chain.* Journal of Enterprise Information Management **18**(4): 427-440

Dijkman RM, B. Sprenkels, T. Peetersa, A. Janssen. 2015. *Business models for the Internet of Things*. International Journal of Information Management **35**(6): 672–678

German federal office for statistics. 2015. *Produzierendes Gewerbe. Beschäftigte, Umsatz und Investitionen der Unternehmenund Betriebe des Verarbeitenden Gewerbes sowie des Bergbaus und der Gewinnung von Steinen und Erden*. Available at: https://www.destatis.de/DE/Publikationen/Thematisch/IndustrieVerarbeitendesGewerbe/Strukturdaten/BeschaeftigteUmsatzInvestitionen2040421147004.pdf?__blob=publicationFile (accessed date January 7, 2015)

Gordon, R. 1980. *Interviewing: Strategy, techniques and tactics.* Dorsey Press, Homewood, IL

Günterberg, B., H. Wolter. 2002. *Unternehmensgrößenstatistik 2001/2001 - Daten und Fakten*. Institut für Mittelstandsforschung, Bonn

Hervas-Oliver J., F. Sempere-Ripoli, C. Baronat-Moll. 2014. *Process innovation strategy in SMEs, organizational innovation and performance: a misleading debate?* Small Business Economics **43**: 873–886

Holsti, O. 1968. *Content analysis*. In: Lindzey G, Aronson E (eds) The handbook of social psychology. McGraw-Hill, New York, 596-692

Kagermann H., W. Wahlster, J. Helbig. 2013. *Umsetzungsempfehlungen für das Zukunftsprojekt Industrie 4.0. Abschlussbericht des Arbeitskreises Industrie 4.0*. Deutsche Akademie der Technikwissenschaften Berlin

Kraiczy, N., A. Hack, F. Kellermanns. 2014. *CEO innovation orientation and R&D intensity in small and medium-sized firms: the moderating role of firm growth*. Journal of Business Economics **85**:851-872

Lee, K. 2015. The Internet of Things (Internet of Things): *Applications, investments, and challenges for enterprises.* Business Horizons **58**(4): 431–440

Lee, X. 2015. *Made in China 2025: A New Era for Chinese Manufacturing*. Cheung Kong Graduate School of Business Knowledge. http://knowledge.ckgsb.edu.cn/2015/09/02/technology/made-in-china-2025-a-new-era-for-chinese-manufacturing/ Accessed 16 December 2015

Maxwell, J. 1996. *Qualitative research design*. Sage, Thousand Oaks

Nguyen, T., M. Newby, M. Macaulay. 2015. *Information Technology Adoption in Small Business: Confirmation of a Proposed Framework.* Journal of Small Business Management **53**(1): 207-227

Organization for Economic Co-operation and Development (2013) Available at: http://www.oecd-library.org/docserver/download/3011045ec028.pdf?expires=1450113604&id=id&accname=guest&checksum=92A44F075701944AD2204D95ABE3CC54. (accessed date January 7, 2015)

Patton, M. 2002. *Qualitative research and evaluation methods*, 3rd edn. Sage, Thousand Oaks

Pieri F., E. Zaninotto. 2011. *Vertical integration and efficiency: an application to the Italian machine tool industry.* Small Business Economics **40**: 397–416

Revest V., A. Sapio. 2012. *Financing technology-based small firms in Europe: what do we know?* Small Business Economics **39**: 179-205

Rochina-Barrachina M., J. Manez, J. Sanchis-Llopis. 2010. *Process innovations and firm productivity growth*. Small Business Economics **34**: 147–166

Sadowski B., C. Maitland, J. van Dongen. 2002. *Strategic use of the Internet by small- and medium-sized companies: an exploratory study*. Information Economics and Policy **14**(1): 75-93

Yoona J., J. Shinb, S. Suhc. 2012. *A conceptual framework for the ubiquitous factory*. International Journal of Production Research **50**(8): 2174-2189

Zheng J, N. Caldwell, C. Harland, P. Powell, M. Woerndl, S. Xu. 2004. *Small firms and e-business: cautiousness, contingency and cost-benefit.* Journal of Purchasing & Supply Management **10**:27–39

Zhou L, A. Chong, E. Ngai. 2015. *Supply chain management in the era of the internet of things.* International Journal of Production Economics **159**: 1-3.