Proceedings ASTRAtech International Conference
Vol. 1 October 2024, 13-21
https://doi.org/10.52453/aic.v1i0ctober.442

Systematic analysis on industry 4.0 implementation in SME: key succes factors and challenges

Selamat Walmanto Hia*

Operational for Excellence Department, PT. ABA, Jakarta, Indonesia

* Corresponding author: selamat.walmanto@gmail.com

Abstract

The implementation of Industry 4.0 (I4.0) technologies in Small and Medium-sized Enterprises (SMEs) is crucial for their competitiveness and sustainability. However, the adoption of I4.0 is often hindered by various challenges. This research aims to identify the key success factors and barrier associated with the implementation of I4.0 in SMEs. A comprehensive literature review was conducted to analyze the existing research on I4.0 and its applications in SMEs. The study found that financial investment, management support, employee capability, are key success factors for the implementation of I4.0 in SMEs. Additionally, human capital readiness, flexibility to adopt the changes, prior study before embarking I4.0, and understand the benefit of digital technologies are crucial for successful adoption of I4.0 technologies. The study also highlights the challenges faced by SMEs in implementing I4.0, including financial challenges, lack of knowledge, insufficient training, reluctant to change, lack of management support and data security. The findings of this study provide valuable insights for SMEs and policymakers to develop effective strategies for the implementation of I4.0 and to overcome the associated challenges.

Keywords: industry 4.0, smes, success factor, technology

1. Introduction

Industry 4.0's provenance lies in the powerhouse of German manufacturing. However, the conceptual idea has since been widely adopted by other industrial nations within the European Union, and further afield in China, India, and other Asian countries (Gilchrist, 2016). The name Industry 4.0 refers to the fourth industrial revolution, with the first three coming about through mechanization, electricity, and IT. The fourth industrial revolution, also known as Industry 4.0 (I4.0), is transforming the manufacturing landscape by integrating advanced technologies such as artificial intelligence, automation, and the Internet of Things (IoT). By integrating advanced digital technologies and smart automation into production processes, Industry 4.0 enables a level of optimization, flexibility, and efficiency thus far unseen in industrial manufacturing (George, 2024).

IR4.0 started in the year 2012 when future industry development trends characterized the 4th Industrial Revolution to achieve more intelligent manufacturing processes, including reliance and construction of Cyber-Physical Systems and the implementation and operation of smart industries that use advanced techniques and technologies (Yu and Schweisfurth, 2020). IR4.0 has been defined as the new chapter in the digitalization of the manufacturing sector. It brings a promisingly exponential increase in efficiency and productivity, particularly to small and medium enterprises (SMEs). By embracing IR4.0, SMEs would have a better opportunity to

Proceedings ASTRAtech Conference is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License

increase their productivity and efficiency (Enterprises et al, 2016). Main technologies to implement Industry 4.0 include Internet of Things (IoT) cloud computing, big data, cyber security, advance robotics, 3D printing and many more as described in Figure.1 (Saturno et al, 2018; Haseeb et al., 2019).

Figure 1. Industry 4.0 technology
Source: (Saturno et al, 2018)

While large companies are already leveraging these technologies to enhance their competitiveness, small and medium-sized enterprises (SMEs) are facing significant challenges in adopting I4.0. This is due to the lack of resources, expertise, and established methods and tools for implementing these technologies effectively. Implementing I4.0 in SMEs is crucial for their competitiveness and sustainability. The integration of advanced technologies can enhance productivity, reduce costs, and improve product quality. However, SMEs face unique challenges in adopting I4.0 due to limited resources and expertise. For instance, a study by (Matt, 2021) highlights the challenges that SMEs will face in the coming years relating to AI, automation, and new technology. Another study by (Yu and Schweisfurth, 2020) found that, on the technology level, the factors that drive SMEs' implementation of I4.0 technologies include the availability of funding, the level of government support, and the availability of skilled labour (Matt, 2021).

Small and Medium-sized Enterprises (SMEs)

SMEs hold a position of paramount global significance. With estimates of 400 million SMEs worldwide, these companies represent not only the economic backbone of many economies but also the source of approximately two-thirds of the total workforce (Enterprises et al., 2016). The role of SMEs in strengthening economies has been recognised to have an impact on GDP, employment generation and the creation of conditions for strengthening chains (Rojas-Berrio, 2022). As major industrial players, Small and Medium Sized Enterprises (SMEs) have to meet ever more complex customer needs. The European Union defines an SME as an enterprise that has revenue of less than €50 M and no more than 250 employees. In Europe, SMEs account for 67.1% of the jobs in the private sector, a figure that has risen to more than 80% for industrial companies (Moeuf et al., 2020). In Malaysia define manufacturing SME as enterprise that had no more than 200 employees and sales turn over less than RM50M. Small and medium enterprises (SMEs) are a business group which could survive when the economic crisis hit developing countries such as Indonesia (Mariyudi, 2019). SMEs in the Indonesian market is no exception to other firms in other markets and countries which should be encouraged to use innovation as a tool to improve both competitive advantage and business growth performance.

According to Indonesian law Based on the provision in Law No. 20 of 2008 the definition for SME with annual sales less than Rp. 50,000 million annually (Law, 2008). SME in Indonesia plays a significant role in distributing development results, increasing national economic growth, and reducing poverty, and MSMEs are recognized worldwide for their unique contribution to the economy (Santoso et al., 2022). SME nationally and in various regions in Indonesia, and also for economic growth in various countries, have an essential role in the development and growth of income (GDP and GRDP), providers and absorbing employment, reducing poverty, increasing the investment's total amount, increasing foreign trade through exports, and contributing taxes as a source of state revenue (Irawan, 2021). Most of the countries agree that SME have an important role in the development of industries in a country. So the majority of the people consider Small and Medium Enterprises as as "seed" for economic development (Al-haddad, 2019; Morina, 2020; Houghton, 2017).

Role of Industry 4.0 in Small and Medium-Sized Enterprises (SMEs)

The motivation to implement I.40 for SME are improve flexibility, cost, efficiency, quality and competitive advantage. They are found to be the key benefits to Industry 4.0 adoption in SMEs. Whilst many SMEs show a desire to implement Industry 4.0 technologies for these reasons, financial and knowledge constraints are found to be key challenges (Masood and Sonntag, 2020). According to study conducted by (Mariyudi, 2019) and (Al-ansari, 2020) innovation is an important success factor in providing a competitive advantage and has a positive impact on sustainable economic development and business growth. Although there are some potential benefits, SMEs hesitate to implement advanced manufacturing technologies due to the high risk. Also, the size of the company is an important critical factor in effective implementation. Smaller SMEs focus more on operational aspects of technology implementation, while larger SMEs develop strategic planning, business formalisation and control systems to support the implementation process. According to Rojas et al., (2022), there are two factors influencing 4.0 technology adoption in manufacturing SMEs in an emerging country, including lack of resources to make investment and reluctant to change as internal issue. While external issue is, lack of connectivity is an inherent issue in government policies because it is an issue that companies could not control, given the large investments required to achieve it.

Despite the growing importance of I4.0 for SMEs, there is a significant research gap in understanding the key success factors and challenges associated with its implementation in these organizations. Existing studies have primarily focused on large companies, leaving a void in the understanding of the specific needs and requirements of SMEs. Moreover, the literature lacks comprehensive frameworks and practical tools for SMEs to successfully implement I4.0. This study aims to address the research gap by identifying the key success factors and challenges faced by SME associated with the implementation of I4.0 in SMEs and then development of implementation framework.

2. Methodology

In To conduct a comprehensive literature review on the adoption of Industry 4.0 technologies by small and medium enterprises (SMEs), a systematic approach will be employed. The research will begin by identifying relevant academic databases. Keywords such as "Industry 4.0," "SMEs," "key success factors," and "challenges" will be used to search for peerreviewed articles, conference papers, and industry reports. The literature review focus on the current state of Industry 4.0 technology adoption in SMEs, highlighting the challenges and benefits of implementation. It will also examine existing frameworks and models for implementing Industry 4.0 technology in SMEs. The review will cover both theoretical and practical aspects of Industry 4.0 technology adoption in SMEs. The work starts from searching article with topic implementation of industry 4.0 in small medium enterprise, key success factor, challenge and barrier of its implementation. The research focus on journal published within 2019-2023 period which published in English

reputable journal. This timeframe ensures that the review includes the most current and relevant research findings. Unclears year of publication and publisher will be excluded in analysis. Inclusion and Exclusion Criteria The selection process will involve applying specific inclusion and exclusion criteria. Inclusion criteria will focus on studies that explicitly address Industry 4.0 technologies (e.g., IoT, AI, big data, and automation) within the context of SMEs. Studies that discuss key success factors, challenges, and case studies of successful implementation will be prioritized. This process will ensure the relevance and quality of the literature reviewed. Data Extraction and Analysis, once the relevant literature is identified, a structured data extraction process will be followed. Key information such as authors, publication year, research objectives, methodologies, findings on key success factors, and challenges will be extracted and tabulated. Thematic analysis will be used to identify common themes and patterns across the studies. This approach will allow for the synthesis of findings, providing a clear understanding of the critical success factors and challenges SMEs face when adopting Industry 4.0 technologies. The results will be categorized and analysed. The research method described in Figure 2.

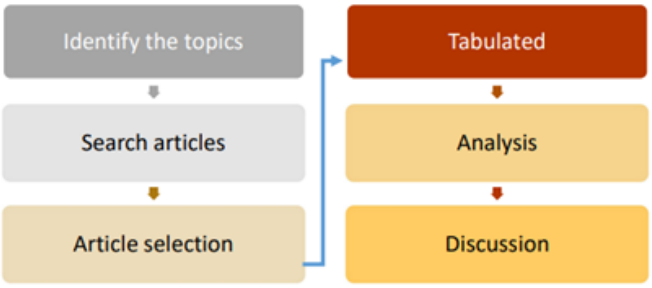

Figure 2. Research methodology

3. Result and Discussion

Based on article searching, 35 journals have been found, but only 20 articles meet criteria, studies that discuss key success factors, challenges I4.0 implementation in the context of SMEs. The distribution of publication article based on year described in Figure 3. It can be seen that the publication about implementation 4.0 in SME still in hot issue in last 5 years. The following can be seen in Figure 3.

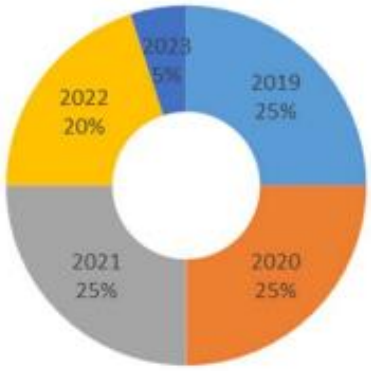

Figure 3. Distribution based on year

Article distribution based on data described in Figure 4. The publication came from many countries (13 countries), involved Europe, Asia and South Americas. Industry 4.0 application for SME are still concern for researcher in many countries. Most of the article publish in Europe continent (about 65%), it is probably because SMEs are the backbone of European economy, and thus they become an interesting context to study and smart manufacturing is one of the priorities to which the European Union is dedicating specific development programmes

(Agostini and Nosella, 2020). While in emerging counties study reveal that lack of resources to make an investment in infrastructure and connectivity is a common obstacle (Rojas-Berrio et al., 2022). The following can be seen in Figure 4.

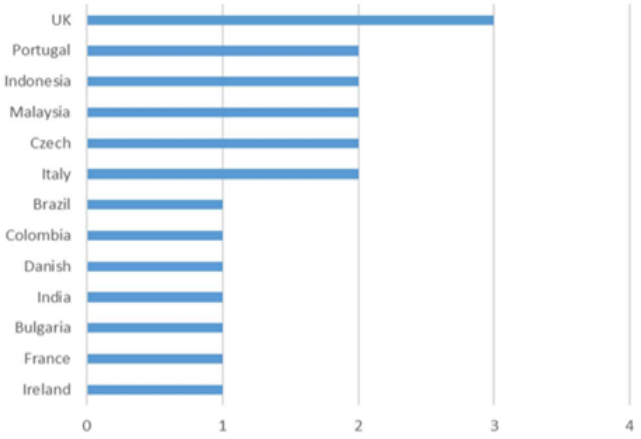

Figure 4. Publication by countries

Based on the selected articles many 4.0 tools, technologies and concept that suitable to SMEs have been discussed as described in Figure 4 (Nwaiwu, 2020; Menon and Shah, 2020). Four major technologies include IoT, big data analytic, CPS and cloud computing. However, most these technologies are not well mastered by SMEs. Beside that these tools required to much investment. While SMEs are also recognized for their low investment capability (Moeuf et al., 2018). Some of the SME have trying implemented these tools, but still in early stage. Robot welding, RFID have been used as self-initiated project in one SME in Czech even the implementation result remain low (Pfeifer, 2021). Trial on application of machine learning also has been done for machine health real time monitoring (K. Velmurugan, 2021). However, there is an evidence on SME in UK that 4.0 technology has been in place before Industry 4.0 (Jones et al., 2019). Certain SME's have perceived the importance of digitalisation as they were obliged to refine the product quality or process to meet buyer or OEMs demands (Thakkar, 2012). The following can be seen in Figure 5.

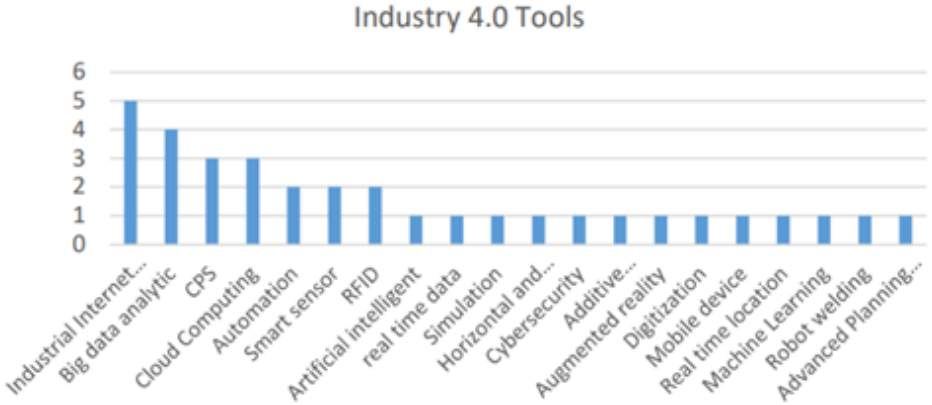

Figure 5. Industry 4.0 technologies for SME

Only three of the articles used case study method on real implementation of 4.0 in SME (Figure 5). One of SME in UK has implemented the technologies in mature stages, including implementation of IoT, autonomous robot, cloud computing, additive manufacturing, augment reality, simulation and horizontal and vertical IT system integration. This company engage in manufacturing of special purpose machinery (medical device, aerospace and military) (Jones et al., 2019). Implementation of IoT and machine learning to monitor asset (K. Velmurugan, 2021). Application of Robot welding, Advanced Planning Systems and RFID in aluminium and metal

machining (Pfeifer, 2021). From the literature there are still lack of evidence on implementation of 4.0 technologies in SME due to some challenges. The following can be seen in Figure 6.

Figure 6. Article based on research method

Data from article have been extracted, key success factor in implementation of 4.0 in SME described in Figure 6. Financial support is the main key success factor, following by employee training and high level of management support. Financial support id significantly important since technology require investment (Rauch and Vickery, 2020). Study reveal that there is positive corelation between management support and the success of technology adoption (Garcia-Ortega et al., 2021). One of the key elements of Industry 4.0 is the technical competency that must support the exploitation of these technologies. Skills and expertise are key in the success of an Industry 4.0 project, but this is often missing in SMEs (Garcia-Ortega et al., 2021). The following can be seen in Figure 7.

Figure 7. Key success factor of industry 4.0 implementation in SME

Barrier for industry 4.0 implementation in SMEs are lack of skill and knowledge about Industry 4.0 (Jones et al., 2019). SME more focus on improving operation and reduce cost. Therefore, solution for this, before embarking Industry 4.0 SME need to prepare the employee training on 4.0 knowledge. Financial efforts can be particularly overwhelming for SMEs that often do not have enough resources required to pursue these technology investments (Agostini and Nosella, 2020). Other barrier are reluctance to change, lack of understanding of the strategic importance of Industry 4.0, lack of management support and data security including stolen data information as described in Figure 8.

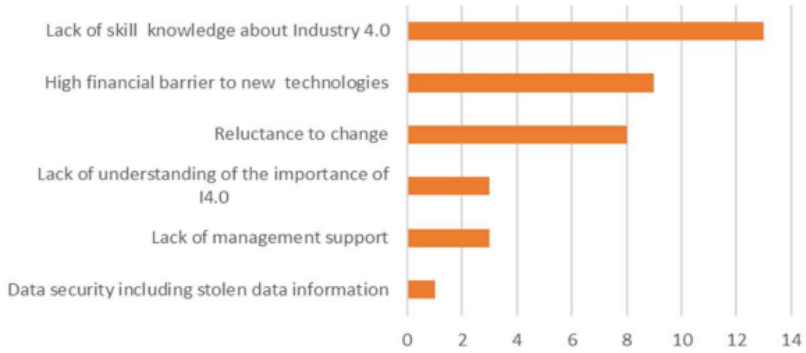

Figure 8. Industry 4.0 implementation barrier in SME

4. Conclusion

Despite a lack of examples showcasing implementation of industry 4.0, many SMEs show a desire to implement Industry 4.0 technologies due to its benefit. Knowledge constraints and financial are found to be key challenges. The lack of adequate skill, the reluctance to change, lack of understanding of the benefit of I4.0 are continuous challenges for the SME. Industry 4.0 transformation is still slow-going, especially within SME companies. Training is needed to support SMEs in the early stages of digitalisation to increase understanding of core concepts, of Industry 4.0, available technologies, data handling, upskilling and training, and strategic management support. Top management should realize the importance of appraising the benefits offered by the implementation of I4.0. Future research should more focus on showcasing of technology 4.0 implementation in SME.

References

A. Gilchrist, Industry 4.0 The Industrial Internet of Things. New York: Springer, 2016.

A. S. George, "The Fourth Industrial Revolution : A Primer on Industry 4 . 0 and its Transformative Impact Partners Universal Innovative Research Publication (PUIRP) The Fourth Industrial Revolution : A Primer on Industry 4 . 0 and its Transformative Impact," no. February, 2024, doi: https://doi.org/10.5281/zenodo.10671872

K. Schwab, The Fourth Industrial Revolution. Currency, 2017.

A. Shahzad, M. S. A. bin Zakaria, H. Kotzab, M. A. M. Makki, A. Hussain, and J. Fischer, "Adoption of fourth industrial revolution 4.0 among Malaysian small and medium enterprises (SMEs)," Humanit. Soc. Sci. Commun., vol. 10, no. 1, pp. 1– 14, 2023, doi: https://doi.org/10.1057/s41599-023-02076-0.

M. Saturno, V. Moura Pertel, F. Deschamps, and E. De Freitas Rocha Loures, "Proposal of an Automation Solutions Architecture for Industry 4.0," DEStech Trans. Eng. Technol. Res., no. icpr, 2018, doi: https://doi.org/10.12783/dtetr/icpr2017/17675

M. Haseeb, H. I. Hussain, B. Ślusarczyk, and K. Jermsittiparsert, "Industry 4.0: A Solution Towards Technology Challenges of Sustainable Business Performance," SocSci., vol. 8, no. 5, 2019, doi: https://doi.org/10.3390/soc.sci8050154

D. T. Matt, V. Modrák, and H. Zsifkovits, Implementing Industry 4.0 in SMEs: Concepts, Examples and Applications. 2021.

F. Yu and T. Schweisfurth, "Industry 4 . 0 Technology Implementation In Smes – A Survey In The Danish- German Border Region International Journal of Innovation Studies Industry 4.0 Technology Implementation in Smes E A Survey in The Danish-German Border Region," Int. J. Innov. Stud., vol. 4, no. 3, pp. 76–84, 2020, doi: https://doi.org/10.1016/j.ijis.2020.05.001

M. Enterprises et al., "Small & Medium-Sized Enterprises What National Action Plans say on Small & medium-sized enterprises," 2016. https://globalnaps.org/issue/small-medium-enterprises-smes/

S. Rojas-Berrio, J. Rincon-Novoa, M. Sánchez-Monrroy, R. Ascúa, and L. A. Montoya-Restrepo, "Factors Influencing 4.0 Technology Adoption in Manufacturing SMEs in an Emerging Country," J. Small Bus. Strateg., vol. 32, no. 3, pp. 67–83, 2022, doi: https://doi.org/10.53703/001c.34608

A. Moeuf, S. Lamouri, R. Pellerin, S. Tamayo-Giraldo, E. Tobon-Valencia, and R. Eburdy, "Identification of Critical Success Factors, Risks and Opportunities of Industry 4.0 in SMEs," Int. J. Prod. Res., vol. 58, no. 5, pp. 1384–1400, 2020, doi: https://doi.org/10.1080/00207543.2019.1636323

M. Mariyudi, "Success Factors of SMEs: The Case of Indonesia," Int. J. Bus. Innov. Res., vol. 19, no. 2, 2019, doi: https://doi.org/10.1504/IJBIR.2019.10014223

Republic of Indonesia, Law Of The Republic Of Indonesia. 2008.

H. W. Santoso, P. Levina, and R. Lim, "Definition And Criteria Of MSME In Indonesia : Does It Have Ambiguous Interpretations?," J. of. Entrep. Financ., vol. 2, no. 3, pp. 219–231, 2022.

A. Irawan, K. Sukiyono, A. Info, and L. Study, "The Role Of Small And Medium Enterprises (SME)," Int. J. Soc. Sci., vol. 1, no. 4, pp. 467–472, 2021.

L. Al-haddad, M. S. Sial, I. Ali, R. Alam, N. V. Khuong, and T. H. Thuy, "The Role of Small and Medium Enterprises (SMEs) in Employment Generation and Economic Growth : A Study of Marble Industry in Emerging Economy," vol. 10, no. 6, pp. 174–187, 2019, doi: https://doi.org/10.5430/ijfr.v10n6p174

D. Morina, "The Role Of Smes On The Economic Development : Kosova ' S Case," no. January 2016, 2020, doi: https://doi.org/10.2139/ssrn.2820980

J. Houghton, "The role of Small and Medium Scale Enterprise in Local Economic Development (LED)," J. Bus. Retail Manag. Res., vol. 11, no. 2, pp. 133–139, 2017.

T. Masood and P. Sonntag, "Industry 4.0: Adoption Challenges And Benefits for SMEs," Comput. Ind., vol. 121, no. 2020, p. 103261, 2020, doi: https://doi.org/10.1016/j.compind.2020.103261

Y. Al-ansari, M. Altalib, and M. Sardoh, "Technology Orientation , Innovation and Business Performance : A Study of Dubai SMEs," Int. Technol. Manag. Rev., vol. 3, no. 1, pp. 1–11, 2013.

L. Agostini and A. Nosella, "The Adoption of Industry 4.0 Technologies in SMES: Results Of An International Study," Manag. Decis., vol. 58, no. 4, pp. 625–643, 2020, doi: https://doi.org/10.1108/MD-09-2018-0973

F. Nwaiwu, M. Duduci, F. Chromjakova, and C. A. F. Otekhile, "Industry 4.0 concepts within the czech sme manufacturing sector: An empirical assessment of critical success factors," Bus. Theory Pract., vol. 21, no. 1, pp. 58–70, 2020, doi: https://doi.org/10.3846/btp.2020.10712

S. Menon and S. Shah, "Are SMEs Ready for Industry 4.0 Technologies: An Exploratory Study of i 4.0 Technological Impacts," Proc. Int. Conf. Comput. Autom. Knowl. Manag. ICCAKM 2020, pp. 203–208, 2020, doi: https://doi.org/10.1109/ICCAKM46823.2020.9051550

A. Moeuf, R. Pellerin, S. Lamouri, and S. T. Giraldo, "Industry 4 . 0 and the SME : a Technology-Focused Review of The Empirical Literature, Process Saf. Environ. Prot., vol. 12, no. 4, pp. 408–425, 2018, [Online]. Available: https://doi.org/10.1016/j.psep.2018.05.009.

M. Rolf Pfeifer, "SMEs in Failed Transition Towards Industry 4.0: A Case Study of a Czech SME," J. Innov. Bus. Best Pract., vol. 2021, pp. 1–16, 2021, doi: https://doi.org/10.5171/2021.707843

K. Velmurugan, P. Venkumar, and P. R. Sudhakara, "SME 4.0: Machine Learning Framework for Real-Time Machine Health Monitoring System," J. Phys. Conf. Ser., vol. 1911, no. 1, pp. 0–8, 2021, doi: https://doi.org/10.1088/1742-6596/1911/1/012026

M. Jones, L. Zarzycki, and G. Murray, "Does Industry 4.0 Pose A Challenge For The Sme Machine Builder? A Case Study and Reflection of Readiness for a UK SME," IFIP Adv. Inf. Commun. Technol., vol. 530, pp. 183–197, 2019, doi: https://doi.org/10.1007/978-3-030- 05931-6_17

J. Thakkar, A. Kanda, and S. G. Deshmukh, "Supply Chain Issues in Indian Manufacturing SMEs: Insights from six case studies," J. Manuf. Technol. Manag., vol. 23, no. 5, pp. 634–664, 2012, doi: https://doi.org/10.1108/17410381211234444

E. Rauch and A. R. Vickery, "Systematic Analysis of Needs and Requirements for The Design of Smart Manufacturing Systems in SMES," J. Comput. Des. Eng., vol. 7, no. 2, pp. 129–144, 2020, doi: https://doi.org/10.1093/jcde/qwaa012

B. Garcia-Ortega, M. A. Lopez-Navarro, and J. Galan-Cubillo, "Top Management Support in the Implementation of Industry 4.0 and Business Digitization: The Case of Companies in the Main European Stock Indices," IEEE Access, vol. 9, no. July, pp. 139994–140007, 2021, doi: https://doi.org/10.1109/ACCESS.2021.3118988

B. Garcia-Ortega, J. Galan-Cubillo, and B. De-Miguel-Molina, "Assessing the Senior Management Support and Approach to Business Digitisation. The Case of Top Finish and Spanish Companies," no. September 2021, pp. 1–8, 2022, doi: https://doi.org/10.4995/bmt2021.2021.13638