# An Implementation of Digital Technologies to Improve Productivity and Reduce Non-value Adding Activities in the Production Process

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## ABSTRACT

In today's smart manufacturing environment, the textile industry faces challenges such as efficiency, sustainability, and a quick response to clients' dynamic requirements as well as productivity that can ensure its survival. Production has been influenced due to a lack of technological advancement, leading to a negative effect on overall performance. Although the relevance of the use of information and communications technology tools to design more reliable and improved processes is still an unexplored area.

The aim of the study is to present the benefits of using software-oriented tools in the textile industry, as one of the most vulnerable types of industries. Namely, the research was conducted in a textile factory in which an intelligent platform was installed for gathering, measuring, and processing data in real-time in terms of the productivity of the manufacturing process.

For the purpose of this research, the methodology of collecting, analyzing, and comparing data was implemented.

The findings indicate that the implementation of appropriate digital technologies allows the reduction of non-value adding activities and the improvement of the overall productivity of the production process. In addition, this smart platform will serve as a technology benchmark and a roadmap for other textile factories, especially in emerging economy countries.

**KEYWORDS:** *Digital technologies, Software-based tools, Non-value adding activities, Productivity, and Production process.*

# INTRODUCTION

Nowadays, most companies are moving towards higher technology by introducing Industry 4.0 ideas (Tortorella et al., 2020). The digitization of industry and the development of "advanced manufacturing" occupy an essential position for maintaining competitiveness by increasing the manufacturing efficiency of processes and determining strategic globalization decisions (Stentoft and Rajkumar, 2020). In essence, Industry 4.0 is more of a driving force than the result of innovations and also it is an inherently vague imagined future that provides an orientation to various organizations. In addition to manufacturing, Industry 4.0 is influencing a paradigm shift in different sectors, such as construction, healthcare, transport, the energy sector, and the textile industry (Meyer, 2019).

Speaking about the textile industry, this has been facing various challenges related to technology. Production has been influenced negatively due to a decrease in technological advancement, leading to an effect on overall performance. Namely, textile manufacturing as a labor-intensive industry is based on human skills and capabilities to a great extent. The traditional approach for managing all value chain operations in the textile industry means coping with various unexpected or expected non-value adding activities which lead to productivity decreasing. Thus, the traditional approach to quality control implies inspections by supervisors, selection of non-conformities, and rework. Furthermore, bottlenecks and delays that consequently occurred are treated as activities that do not bring any added value (Conci and Proença, 2002). The non-value adding activities are a pure waste and should be targeted for immediate removal because they generate only waste, increase the price, delay processing time, and are not valuable for the product. In broader concept, value-adding activities are those activities for which customers pay to a textile factory or any physical changes in shape or character of products happens. In essence, apparel customers pay for activities such as fabric cutting, sewing, buttoning, the finishing process, and ironing the garment. (Ahmad et al., 2020).

As aforementioned, Industry 4.0 technologies offer opportunities and promote changes in the world of work and understanding how these technologies are linked to productivity improvement in the textile industry is an issue that is worth addressing. Besides that, Industry 4.0 promotes production which automatically increases the overall performance and can resolve various issues through modern technologies (Wang et al., 2016; Fogaca et al., 2022; Schneider, 2018).

From that point of view, it is expected that this new paradigm, which employs digital tools for coordinating all value chain interactions, will significantly eliminate non-value adding activities and improve productivity. In the same context, the utilization and production capacity can be improved, and also, the duration of the process can be reduced. All these issues lead to reducing the operation costs and an improvement of the overall success and sustainability of the particular business. Nevertheless, the main prerequisite for the implementation of Industry 4.0 technology in the existing textile factories is to implement digital technologies in the direction to establish a solid ground for further improvements in the spirit of Industry 4.0 perspectives (Imran et al., 2018).

Therefore, the objective of this paper is to research the benefits of using digital tools for data collecting and processing towards faster decision-making, more accurate and quick reporting, and reducing the costs related to non-value adding activities in one textile factory in an emerging economy. The created database is a useful digital platform in the manager's hands to make the right decision in terms of enhancing productivity in the organization. The research is part of a wider investigation towards the creation of the Industry 4.0 platform under the influence of software-based technologies.

In the next section, some background on the use of Industry 4.0 technologies in the textile industry is provided, followed by findings, and a discussion of these findings. Finally, conclusions are drawn in the last section of the paper. The results obtained in this research will be used to create a structured model for improving the level of productivity, under the implementation of digital technologies.

## THEORETICAL BACKGROUND

According to Balogun et al. (2019) and Fatorachian (2018), in today's smart manufacturing environment, the textile industry faces challenges such as efficiency, sustainability, and a quick response to a client's requirements as well as product quality and regulatory compliance which can ensureit's the industry's survival. It is relevant since globalization has made business values constantly change (Imran et al., 2018; Denvura et al., 2019). Lekamge and Ekanayake (2021) take into consideration the nature and complexities of garment production and conclude that the establishment of labor-saving technology in the textile industry is more than difficult. In this context, Khorram et al. (2019) discuss the management efforts in some of the large apparel companies to track and monitor different stages of manufacturing and gain numerous benefits such as decreased operational costs and ensuring the on-time delivery of goods. From this perspective, it is expected that this new paradigm, which employs digital tools will achieve market sustainability and a competitive edge (Ahmed et al. 2020; Demeter et al., 2020; Ghobakhloo et al., 2021; Judit et al. 2018; Dalenogare et al., 2018; Howaldt et al., 2017). Yet, the development of progressive technologies resulting from modern software-based tools and highly sophisticated knowledge as a solid ground for the further implementation of Industry 4.0 technologies is stressed by Rajnoha and Lorincová (2015).

Aguilar-Rodriguez et al. (2021) and Grzybowska and Łupicka (2017) highlight the benefits of the development of the Industry 4.0 concept in various types of businesses, including the textile industries. Similar attitudes are presented in the papers by numerous authors, such as Wollschlaeger et al. (2017), Fogaca et al. (2022), Singh et al. (2019), Iqbal et al. (2018), Haseeb et al. (2019), Rajnoha and Lesníková (2016), Shahriar, et al. (2016), Carvalho et al. (2015) and Istrat et al. (2017). Additionally, Wang et al. (2016), and Longo et al. (2017) confirm the need for traditional textile industries to integrate Industry 4.0 technologies in a highly competitive dynamic environment. However, the fact that Industry 4.0 enables textile factories to create decision-making processes that improve overall productivity in textile factories is confirmed by Lee et al. (2018), Grzybowska and Łupicka (2017), Trieu (2017), Wang et al. (2016), Meyer (2019), and Fromhold-Eisebith et al. (2021).

## RESEARCH DESIGN

The organization of manufacturing in a textile factory that is the topic of the research was explained in a study by Stanojeska (2022). The analyzed factory is equipped with two production lines, (i) *"standard or regular line"* and (ii) *"pilot-line equipped with digital devices"*. Both the production lines are characterized by different approaches to control and monitoring. In terms of production, the process can be considered as a set of a few sequentially connected operations stages like cutting, sewing (assembling), buttoning, ironing, packing, and shipment. The main steps of the process flow are shown in Fig. 1

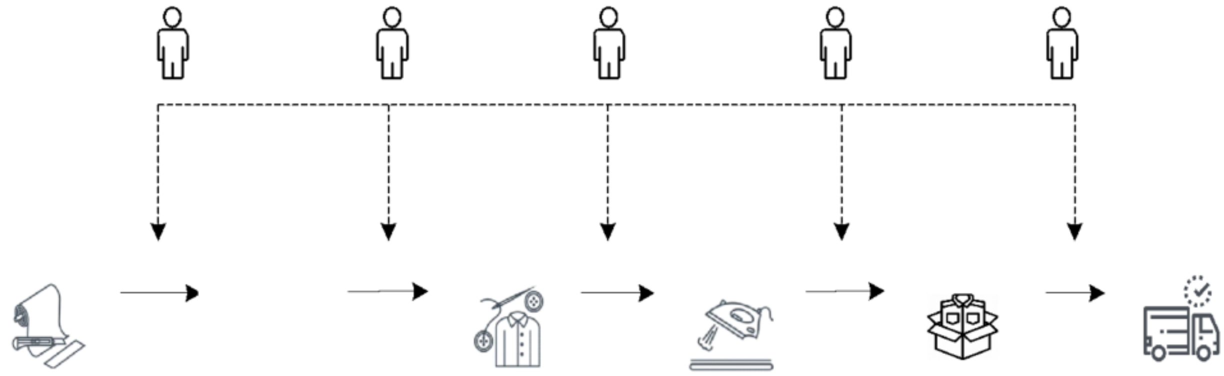

*Fig. 1. Regular production line monitored by the supervisors*

The traditional approach typical for the *"standard/regular line"* implies on-site monitoring of the operations tasks, performed by a few supervisors. Namely, supervisors are responsible for monitoring the performance of each operation of the process flow and determining whether the operation's objectives, such as quality, speed, flexibility, dependability, and costs are kept at an acceptable level. In that sense, after the completion of every single operation, the supervisors make records, which create the database related to the entire process. The collected data represent a platform for making a decision by the management to improve the process, eliminate weaknesses or reduce it to an acceptable level. However, this approach to process monitoring and tracking leads to delayed action because it is impossible to undertake prompt and on-time corrective measures. Consequently, frequent interruptions, bottlenecks, and delays occur, mostly because of spending time on correcting and reworking failures. On the other hand, partial interruptions affect excessive delays in shipment and unfulfilled deadline requirements. At the end of the day, the effect of such an organized process is customer dissatisfaction, decreased competitiveness, and significantly increased operating costs.

Opposite the aforementioned, the other production line - "*the pilot line*" is equipped with information and communications *technology* for tracking and monitoring the manufacturing process (Fig. 2.).

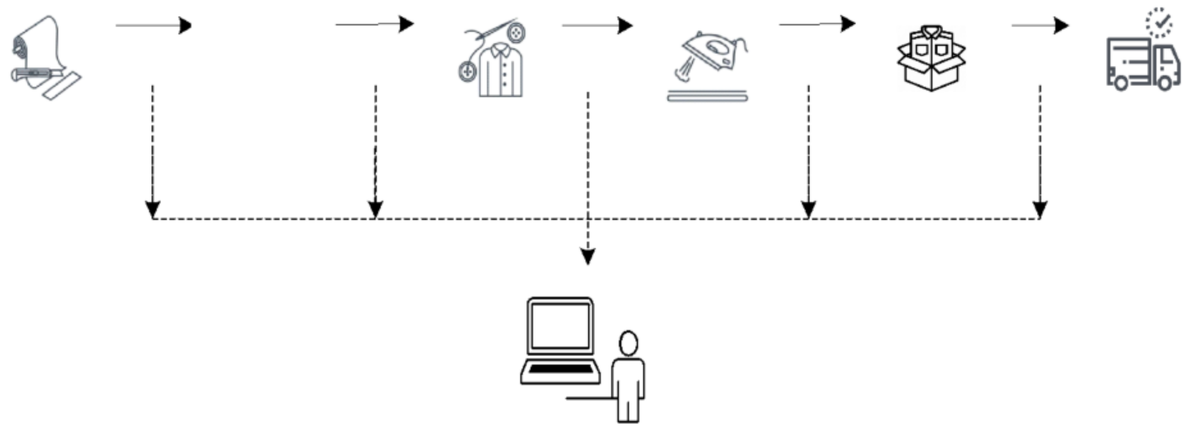

Fig. 2. Pilot production line equipped with digital devices for tracking and monitoring

In essence, the digital platform for full tracking and monitoring of the manufacturing process includes the collection and processing of data using an appropriate fit-to-use software system. Each machine performs a certain operation. Using a controller, the particular operation mechanically performed on the respected machine is loaded as an input in the controller/monitor. Thus, the data is saved in the monitor as long as the operation is performed by the operator. The operation mechanically performed on the respected machine is fully synchronized with the data loaded in the controller. Using a software program designed and developed to fit the process needs and requirements, the collected data from each controller, are accurately processed, and valuable information in terms of the quantity of produced items, the duration of interruptions, points of bottlenecks, anticipated delays, and the number of non-conforming units, in real-time is gathered. Those data create the pool of data that serves as the grounds for further calculation of the efficiency and effectiveness of the process, productivity, capacity, process capability, and similar mechanisms for measuring the process sustainability.

Against the regular line, the tracking and monitoring on the digitalized (pilot) line are performed at each stage of the manufacturing. Every operator enters the predicted data related to the particular unit and task in controllers. On such occasions, only one supervisor is sufficient to monitor the entire process by the main computer unit (Fig. 2).

Yet, the differences in the monitoring and tracking approaches of the two product lines impose the purpose of this research. In that sense, the goal is:

*To determine the effect of the implementation of digital technologies on productivity, by reducing non-value adding time in the production process.*

### *Methodology*

In this research, the methodology of collecting, processing, and comparing data was implemented. Following the goal of the research, the non-value adding activities such as: (i) waiting for assembling, (ii) waiting for buttoning, (iii) waiting for ironing, (iv) quality control, (v) rework, (vi) waiting for packing, and (vii) waiting for delivery, were identified. In that context, the two sets of data were created. The first one was formed using data generated from the digital production line. These data were obtained by the implemented digital technology and stored in the software system for sixteen weeks. The second set of data includes the data generated from the regular production line, for the same period (sixteen weeks). These data were gathered and recorded through on-site monitoring by the supervisors. After collecting data from both lines, the data were processed. In the third step of the research methodology, the comparison of the databases was presented, and conclusions were given.

## RESULTS AND DISCUSSION

According to the implemented research methodology, the gathered data related to the production process performed on the pilot line equipped with digital devices is present in Table 1.

## Table 1. Collected data refers to a pilot line equipped with digital devices

| Week No. | Non-value adding activities on pilot line equipped with digital devices (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Waiting for assembling | Waiting for buttoning | Waiting for ironing | Quality control | Rework | Waiting for packing | Waiting for delivery | Total non-value adding time/week |
| Week 1 | 0.25 | 0.25 | 0.10 | 0.50 | 8.30 | 0.00 | 1.30 | 10.70 |
| Week 2 | 0.30 | 0.20 | 0.15 | 0.60 | 7.70 | 0.00 | 1.50 | 10.45 |
| Week 3 | 0.20 | 0.20 | 0.15 | 0.70 | 7.50 | 0.00 | 2.00 | 10.75 |
| Week 4 | 0.20 | 0.25 | 0.20 | 0.70 | 8.00 | 0.00 | 2.00 | 11.35 |
| Week 5 | 0.25 | 0.25 | 0.15 | 0.60 | 7.50 | 0.10 | 3.00 | 11.85 |
| Week 6 | 0.25 | 0.30 | 0.10 | 0.80 | 7.30 | 0.10 | 2.00 | 10.85 |
| Week 7 | 0.20 | 0.30 | 0.30 | 0.80 | 7.30 | 0.15 | 2.50 | 11.55 |
| Week 8 | 0.30 | 0.25 | 0.30 | 0.70 | 7.00 | 0.15 | 4.20 | 12.90 |
| Week 9 | 0.20 | 0.25 | 0.20 | 0.60 | 7.00 | 0.00 | 5.50 | 13.75 |
| Week 10 | 0.25 | 0.25 | 0.30 | 0.60 | 7.00 | 0.10 | 1.00 | 9.50 |
| Week 11 | 0.25 | 0.20 | 0.25 | 0.50 | 7.10 | 0.05 | 0.00 | 8.35 |
| Week 12 | 0.25 | 0.20 | 0.25 | 0.50 | 7.30 | 0.10 | 0.00 | 8.60 |
| Week 13 | 0.30 | 0.20 | 0.10 | 0.50 | 7.20 | 0.10 | 2.00 | 10.40 |
| Week 14 | 0.25 | 0.25 | 0.15 | 0.60 | 7.00 | 0.10 | 2.50 | 10.85 |
| Week 15 | 0.30 | 0.20 | 0.15 | 0.60 | 7.00 | 0.10 | 1.20 | 9.55 |
| Week 16 | 0.25 | 0.20 | 0.25 | 0.50 | 7.30 | 0.10 | 0.00 | 8.60 |
| **Total** | **4.00** | **3.75** | **3.10** | **9.80** | **117.50** | **1.15** | **30.70** | **170.00** |

WThe data collected by the regular production line is present in Fig. 2.

## Table 2. Collected data refer on a regular line

| Week No. | Non-value adding activities on regular line (h) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Waiting for assembling | Waiting for buttoning | Waiting for ironing | Quality control | Rework | Waiting for packing | Waiting for delivery | Total non-value adding time/week |
| Week 1 | 0.30 | 0.35 | 0.30 | 0.70 | 14.40 | 0.50 | 2.00 | 18.55 |
| Week 2 | 0.40 | 0.35 | 0.25 | 0.80 | 13.80 | 0.50 | 2.00 | 18.10 |
| Week 3 | 0.40 | 0.30 | 0.30 | 0.80 | 13.00 | 0.70 | 3.50 | 19.00 |
| Week 4 | 0.50 | 0.30 | 0.25 | 0.70 | 13.30 | 1.00 | 2.00 | 18.05 |
| Week 5 | 0.50 | 0.40 | 0.20 | 1.00 | 15.00 | 1.00 | 2.50 | 20.60 |
| Week 6 | 0.50 | 0.40 | 0.30 | 1.00 | 14.20 | 1.00 | 4.00 | 21.40 |
| Week 7 | 0.40 | 0.40 | 0.30 | 0.80 | 13.00 | 0.60 | 3.00 | 18.50 |
| Week 8 | 0.30 | 0.30 | 0.40 | 1.00 | 13.80 | 0.70 | 4.50 | 21.00 |
| Week 9 | 0.30 | 0.25 | 0.40 | 1.00 | 14.40 | 0.80 | 5.00 | 22.15 |
| Week 10 | 0.30 | 0.25 | 0.50 | 1.00 | 13.80 | 1.00 | 1.50 | 18.35 |
| Week 11 | 0.30 | 0.30 | 0.40 | 1.00 | 13.00 | 1.00 | 2.50 | 18.50 |
| Week 12 | 0.20 | 0.30 | 0.30 | 1.00 | 13.00 | 1.00 | 3.00 | 18.80 |
| Week 13 | 0.30 | 0.50 | 0.30 | 1.50 | 14.50 | 0.80 | 2.50 | 20.40 |
| Week 14 | 0.40 | 0.40 | 0.40 | 1.50 | 15.50 | 0.90 | 3.00 | 22.10 |
| Week 15 | 0.50 | 0.40 | 0.40 | 1.50 | 13.00 | 1.50 | 3.00 | 20.30 |
| Week 16 | 0.20 | 0.30 | 0.30 | 1.00 | 13.00 | 1.00 | 3.00 | 18.80 |
| **Total** | **5.80** | **5.50** | **5.30** | **16.30** | **220.70** | **14.00** | **47.00** | **314.60** |

The duration of non-value adding activities identified on the line equipped with digital devices is lower compared to the duration of non-value adding activities gathered by the regular production line. In essence, the implemented digital platform provides real-time information about the stability or the variation in the process. Entering data into the controllers means a transfer of the information in real-time, which leads to the opportunity for undertaking quick action and corrective measures for immediately coping with an unexpected problem. Thus, the duration of non-value adding activities that occurred on the regular production line is remarkably shorter than the duration of non-value adding activities related to the digital production line.

According to the findings, the waiting for assembling is longer than 31 per cent on the regular production line. The waiting for buttoning at the regular line is longer by 25 per cent compared with the same issue at the digital production line. Moreover, there is a notifiable difference between the waiting for ironing at the regular line (5.3 h) and the same criteria at the digital line (3.1 h). The time needed for quality control is longer than 40 per cent at the regular line. Despite this, the time required for correction of non-conformed items (rework) is longer by 46 per cent. The findings indicate the time for rework has the highest participation in total non-value adding time. Even about 70 per cent is due to the need for reworking, for both production lines, regular and digital. Basically, reworking is based on the need to fix the failures. The more non-conformity units, the longer the reworking time. However, poor quality has a serious impact on total non-value-added activities. As expected, the gathered results regarding the waiting for packing and delivery are longer at 92 per cent and 35 per cent respectively, on the regular production line, compared with the digital production line. In summary, the total non-value adding time on the regular production line generated for sixteen weeks is 314.6 hours and 200 hours on the digital production line. Speaking through ratios, the duration of the production performed on the regular line is longer than the production performed on the digital line by 46 per cent, at the equal production capacity (the number of produced items). According to the findings, one can conclude that the utilization of the regular line is lower then the digital line because less time is required for the production of the same quantity of units on the digital line.

Regarding the goal of this research, the benefits of the implementation of an innovative digital solution on one of the production lines are more than clear.

As mentioned above, the results obtained in this research will be used to create a structured model for improving the level of productivity in the textile factory, under the implementation of digital technologies.

## CONCLUSION

This research contributes on a practical dimension by explaining the implementation of digital technology as a solid foundation for the further implementation of Industry 4.0 techniques in the textile industries. The implemented digital system for quality control and process monitoring can be recognized as an intelligent platform for further process improvement in the field of Industry 4.0.

The software-based tools to collect and process data according to the performed operational tasks enable full monitoring and tracking of manufacturing and gathering the relevant information in real-time. Regarding the goal of this research, one can conclude the implementation of digital technology brings numerous benefits. The paper presents the positive influence of integrated digital technologies on reducing non-value adding activities in the process. To emphasize once again, the duration of the process performed on the regular line is longer than the production performed on the digital line by 46 per cent, at equal production capacity. It is more than clear the non-value adding activities must be eliminated or reduced to an acceptable level. In that direction, reducing or eliminating those non-value adding activities leads to decreased operations costs and improved operations performance in the factory. Although, non-value adding activities influence the workforce. If the non-value adding time is longer, a higher number of operators is needed. Moreover, the utilization and production capacity is directly influenced by the non-value adding activities. The shorter duration of the non-value adding time leads to higher utilization.

In terms of competitiveness, by using digital technologies customer satisfaction will be increased if the delivery deadlines are respected as well. Namely, the fulfillment of the customer's demands, at the same time means the fulfillment of the enterprise's major objective, because keeping the customer orientation in the textile industry is a key to success. In that sense, the sustainability of the business will be provided and the competitive advantage in the market will be enhanced.

To summarize, the duration of the process is directly associated with operations costs and the overall success of the factory. The implementation of

digital technologies are a smart platform and can serve as a technology benchmarking for other textile factories, especially in emerging economy countries.

Yet, the implemented digital technology for monitoring the manufacturing process in the textile factory is not an ultimate state. In the following period, the digitalization of the regular line is planned.

## REFERENCES:

Aguilar-Rodriguez, I.E., Bernal-Torres, C.A., Aldana-Bernal, J.C., Acosta-Aguinaga, A.G., Artieda-Cajilema, C.H. and Chala, P. (2021). Relationship between social culture, industry 4.0, and organizational performance in the context of emerging economies. *Journal of Industrial Engineering and Management*, 14(4): pp. 750-770. https://doi.org/10.3926/jiem.3560

Ahmad, S., Miskon, S., Alabdan, R. and Tlili, I. (2020). Towards Sustainable Textile and Apparel Industry: Exploring the Role of Business Intelligence Systems in the Era of Industry 4.0. *Sustainability,* 12: pp. 2632. doi:10.3390/su12072632

Balogun, A.-L., Tyler, D., Han, S., Moora, H., Paco, A., Boiten, V.J., Ellams, D. and Leal Filho, W. (2019). A review of the socio-economic advantages of textile recycling. *J. Clean. Prod,* 218: pp. 10–20.

Carvalho, S., Portela, F., Santos, M.F., Abelha, A. and Machado, J. (2015). *Step towards of a homemade business intelligence solution - A case study in textile industry. In New Contributions in Information Systems and Technologies,* Springer: Berlin/Heidelberg, Germany.

Conci, A. and Proença, C.B. (2002). *A system for real-time fabric inspection and industrial decision. SEKE '02: Proceedings of the 14th International conference of Software engineering and knowledge engineering.* Sant'Angelo d'Ischia, Italy.

Dalenogare, L.S., Benitez, G.B., Ayala, N.F. and Frank, A.G. (2018). The expected contribution of Industry 4.0 technologies for industrial performance. *International Journal of Production Economics,* 204: pp. 383-394. https://doi.org/10.1016/j.ijpe.2018.08.019

Demeter, K., Losonci, D., Marciniak, R., Nagy, J., Moricz, P. and Matyusz, Z. (2020). Industry 4.0 through the lenses of technology, strategy, and organization: A compilation of case study evidence. *Vezetéstudomány / Budapest Management Review,* 51(11): pp. 14-25. https://doi.org/10.14267/veztud.2020.11.02

Denuwara, N., Maijala, J. and Hakovirta, M. (2019). Sustainability benefits of RFID technology in the apparel industry. *Sustainability,* 11(22): 6477.

Fatorachian, H. and Kazemi, H. (2018). A critical investigation of Industry 4.0 in manufacturing: Theoretical operationalisation framework. *Prod. Plan. Control,* 29(8): pp. 633–644.

Fogaça, D., Grijalvo, M., and Sacomano Neto, M. (2022). An Institutional Perspective in The Industry 4.0 Scenario: A Systematic Literature Review. *Journal of Industrial Engineering and Management,* 15(2): pp. 309-322. https://doi.org/10.3926/jiem.3724

Fromhold-Eisebith M., Marschall P., Peters R. and Thomes P. (2021). Torn between digitized future and context dependent past – How implementing 'Industry 4.0' production technologies could transform the German textile industry, *Technological Forecasting and Social Change,* 166: 120620.

Ghobakhloo, M., Fathi, M., Iranmanesh, M., Maroufkhani, P. and Morales, M.E. (2021). Industry 4.0 ten years on: A bibliometric and systematic review of concepts, sustainability value drivers, and success determinants. *Journal of Cleaner Production,* 302: 127052. https://doi.org/10.1016/j.jclepro.2021.127052

Grzybowska, K. and Łupicka, A. (2017). Key competencies for Industry 4.0. *Economics and Management Innovations,* 1(1): pp. 250-253. https://doi.org/10.26480/icemi.01.2017.250.253

Haseeb, M., Hussain, H.I., ´Slusarczyk, B. and Jermsittiparsert, K. (2019). Industry 4.0: A solution towards technology challenges of sustainable business performance. *Soc. Sci.* 8(5): 154.

Howaldt, J., Kopp, R., and Schultze, J. (2017). Why Industrie 4.0 Needs Workplace Innovation - A Critical Essay About the German Debate on Advanced Manufacturing. *Workplace Innovation,* pp. 45-60. Springer International Publishing. https://doi.org/10.1007/978-3-319-56333-6_4

Imran, M., Hameed, W. and Haque, A. (2018). Influence of Industry 4.0 on the Production and Service Sectors in Pakistan: Evidence from Textile and Logistics Industries. *Soc. Sci., 7(12):* 246. https://doi.org/10.3390/socsci7120246

Iqbal, M., Soomrani, A.R. and Butt, S.H. A study of big data for business growth in SMEs: Opportunities & challenges. *In Proceedings of the International Conference on Computing, Mathematics and Engineering Technologies* (iCoMET), Sukkur, Pakistan, 3 - 4 May, 2018.

Istrat, V. and Lali´c, N. (2017). Association rules as a decision making model in the textile industry. *Fibres Text. East. Eur,* 25: pp. 8–14.

Judit, O., Karmazin, G., Pet˝o, K. and Popp, J. (2018). Information technology developments of logistics service providers in Hungary. *International Journal of Logistics Research and Applications,* 21: pp. 332–44.

Khorram, M., Torabi, S.A. and Nonino, F. (2019). Why manufacturers adopt additive manufacturing technologies: The role of sustainability. *J. Clean. Prod.*, 222: pp. 381–392.

Lee, C., Huang, G.-H. and Ashford, S.J. (2018). Job insecurity and the changing workplace: Recent developments and the future trends in job insecurity research. *Annual Review of Organizational Psychology and Organizational Behavior,* 5(1): pp. 335-359. https://doi.org/10.1146/annurev-orgpsych-032117-104651

Lekamge, R. and Ekanayake, N. (2021). Internal Quality Failures of Apparel Industry: A Case from Sri Lanka. *Open Journal of Business and Management,* 9: pp. 2389-2406. doi: 10.4236/ojbm.2021.95129.

Longo, F., Nicoletti L. and Padovano, A. (2017). Smart operators in industry 4.0: A human-centered approach to enhance operators' capabilities and competencies within the new smart factory context. *Comput. Ind. Eng.*, 113: pp. 144–159.

Meyer, U. (2019). The emergence of an envisioned future. Sensemaking in the case of "Industrie 4.0" in Germany. *Futures,* 109: pp. 130-141. https://doi.org/10.1016/j.futures.2019.03.001

Rajnoha, R. and Lesníková P. (2016). Strategic performance management system and corporate sustainability concept-specific parametres in Slovak Enterprises. *Journal of Competitiveness,* 8. pp. 107–24.

Schneider, P. (2018). Managerial challenges of Industry 4.0: An empirically backed research agenda for a nascent field. *Review of Managerial Sciencie,* 12(3): pp. 803-848.

Shahriar, A., Wamba, S., Gunasekaran, A., Dubey R. and Childe. S.J (2016). How to improve firm performance using big data analytics capability and business strategy alignment? *International Journal of Production Economics,* 182. pp. 113–31.

Singh, R.K., Kumar, P. and Chand, M. (2019). Evaluation of supply chain coordination index in context to Industry 4.0 environment. *Benchmarking,* 28(5): pp. 1622-1637. https://doi.org/10.1108/BIJ-07-2018-0204

Stentoft, J. and Rajkumar, C. (2020). The relevance of Industry 4.0 and its relationship with moving manufacturing out, back and staying at home. *International Journal of Production Research,* 58(10): pp. 2953-2973. https://doi.org/10.1080/00207543.2019.1660823

Tortorella, G.L., Cawley Vergara, A.M., Garza-Reyes, J.A. and Sawhney, R. (2020). Organizational learning paths based upon industry 4.0 adoption: An empirical study with Brazilian manufacturers. *International Journal of Production Economics,* 219: pp. 284-294. https://doi.org/10.1016/j.ijpe.2019.06.023

Trieu, V. (2017). Getting value from business intelligence systems: A review and research agenda. *Decis. Support Syst,* 93: pp. 111–124.

Wang, L. and Shen, B. (2017). A product line analysis for eco-designed fashion products: Evidence from an outdoor sportswear brand. *Sustainability,* 9(7): 1136.

Wang, S., Wan, J., Li, D., and Zhang, C. (2016). Implementing smart factory of industrie 4.0: An outlook. *International Journal of Distributed Sensor Networks,* 12(1): pp. 517-527. https://doi.org/10.1155/2016/3159805

Wollschlaeger, M., Sauter, T., and Jasperneite, J. (2017). The future of industrial alcohols. *IEEE Industrial Electronics Magazine,* 11(1): pp. 17-27. https://doi.org/10.1109/MIE.2017.2649104