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FACILITATED DISCRETE EVENT SIMULATION FOR INDUSTRIAL PROCESSES: A CRITICAL ANALYSIS

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Abstract
Discrete Event Simulation (DES) is one of the most important simulation techniques in decision-making in several areas. Some authors state that small and large companies can benefit significantly through the utilisation of DES. Literature shows that most DES studies carried out are at large companies. Studies carried out at small and medium-sized enterprises (SMEs) have been mostly explored on a one-off, case-by-case basis, given the characteristics and limitations of smaller companies. In order to expand DES studies in a wide range of companies, this article seeks to consider the SME characteristics and limitations prevent them from broadly adopting traditional ("hard") DES. Then an alternative application of DES in "soft" mode was proposed. A review of facilitated DES frameworks was carried out. The frameworks were critically analysed in this review in relation to their adequacy to specific SME requirements and similar contexts. Finally, some issues and characteristics of these frameworks are presented that make directly applying in these contexts difficult. Furthermore, some suggestions are proposed for developing future facilitated DES frameworks.
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Key Words: Facilitated Modelling, Small and Medium Enterprises, Soft Operational Research, Facilitated Simulation Modelling

1. INTRODUCTION

Discrete event simulation (DES) is one of the main simulation techniques in decision-making in several areas [1]. This technique allows the study of complex systems more quickly when compared to direct experimentation in real systems, which would consume enormous resources [2]. According to [3], DES creates, in a virtual environment, a representation of a real system to test different scenarios without risk and with low cost involved.

DES can assist in understanding and analysing systems, assist in decision making, assist in improving operations, and assist in designing real system changes with less costly errors [4]. Companies ranging from small to large can benefit significantly through the utilisation of DES [4].

There is a vast and growing literature base on DES applications [1]. However, most studies tend to be at large companies, precisely due to the characteristics and limitations of SMEs [4-8].

According to the literature, the main requirements and challenges faced by SMEs, that limit them from adopting new technologies, including DES, can be grouped into four clusters (financial resources, data collection, knowledge, and application complexity). Several authors that carried out studies on SMEs sought to bring new techniques to these companies and stated that these techniques need to consider the characteristics and limitations of SMEs so that they can benefit more [4, 5, 9-12].

This article seeks first to examine the characteristics of SMEs and compare these with the main requirements for traditional ("hard") DES applications. Second, DES applied to SMEs

using the "soft" paradigm will be discussed. Lastly, DES studies in this paradigm will be analysed, seeking to expand DES for SMEs and similar contexts.

The contribution of the paper is related to a few aspects. First, it introduces literature discussions on using facilitated DES to expand DES studies in companies that face difficulties applying it directly, like SMEs and similar contexts. To the best of our knowledge, this has not yet been addressed by literature. This study also provides a critical analysis of facilitated DES frameworks and their suitability for the characteristics and limitations of SMEs. Finally, this article also gives suggestions for future facilitated DES frameworks for industrial processes.

2. LIMITATIONS AND CHARACTERISTICS OF SMES

This section addresses the limitations and characteristics of SMEs. According to some simulation experts, these limitations can also be found in larger companies. Therefore, the recommendations of this article are indicated for companies that present this type of context.

After a literature review, one will better understand SMEs' main requirements and challenges. As presented below, these can be grouped into four clusters (financial resources, data collection, knowledge, and application complexity).

2.1 Financial resources (FR)

One of the most important characteristics of any company is financial resource availability. For SMEs, literature shows that they are financially limited, constituting an obstacle to their growth [4, 8-10, 12, 13]. Lacks financial resources also prevent SMEs from adopting mechanisms to collect large amounts of data and prevent them from hiring qualified personnel with the necessary knowledge to process and use this data [9].

According to [6], data collection and data preparation require the most financial resources for DES studies. SMEs cannot afford expensive automated data collection devices, which is the main difficulty these companies face when adopting DES [5]. O'Kane et al. [8] state that DES studies tend to focus on larger companies, given the costs of simulation tools and the experience needed for developing models, requiring that qualified personnel be hired. Therefore, researchers need to seek ways to help SMEs and similar contexts participate more in these advances while also taking their restrictions into account.

2.2 Data collection (DC)

The issue of data collection at SMEs is a big challenge and a limiting factor when using new technologies. Several studies that sought to implement new technologies and tools at SMEs faced data deficiency issues.

They collect low volumes of data [4, 10], and even operational data is unavailable [6]. There are difficulties in accessing data in this context [14]. Data is often missing or incomplete [9-10, 12]. When data is available, it is usually stored in varying formats [6]. Byrne et al. [5] found that this leads to an inability to engage with the development of simulation models and experimentation using these models because these companies collect few data. According to [15], manufacturing process information is undocumented and held as specific personnel knowledge (managers and key personnel).

2.3 Knowledge (KN)

A lack of knowledge on applying new technologies and tools, especially DES, underestimates the advantages of applying them [4, 5, 7-10]. According to [5], SMEs underestimate the usefulness of DES since they do not see their systems as being complex enough to justify using this technique. SMEs do not fully understand the level of complexity of their systems.

Another aspect is that, although DES is a widespread practice, its approach does not facilitate the active participation of all stakeholders, possessing a lower level of stakeholder engagement compared to system dynamics [1]. Therefore, this ends up distancing stakeholders from applying DES, as the entire process is concentrated in the hands of specialists and researchers, limiting their knowledge of this practice and confidence in its results. Löfving et al. [11] state that SMEs require more descriptive, simple, easy-to-use frameworks. So it can facilitate understanding by stakeholders during the intervention process.

2.4 Complexity (CO)

SMEs often hesitate to apply simulation technologies because they see these processes as time-consuming and complex [16]. However, for Hvolby et al. [16], this is true if the goal is perfection, but SMEs do not typically require a high degree of detail. It is, therefore, possible that very simple models could be applied to improve resource use.

Literature shows that the complexity of applying DES is related to data collection and data preparation, and simulation model development [4, 6]. Therefore, alternatives should be sought to reduce this complexity of DES application, expanding DES studies.

Given the aforementioned, these restrictions result in few studies in the literature on DES for SMEs, leading to a knowledge gap and experience gap in applying DES in these contexts.

Therefore, should be sought ways to expand DES studies to SMEs and similar contexts, which do not require high investments, and involve the main stakeholders in the project, that uses existing data, that is neither time-consuming nor complex, but rather easy to use and easy to understand [4, 10]. Table I shows the SME requirements compared to traditional DES applications.

Table I: Comparison between SME characteristics and DES requirements.

DES requirements	**SME characteristics**	
• Developing precise, detailed models. • Detailed data collection. • Data analysis. • Intervention is completed based on specialised knowledge.	Limited financial resources	• Impediments for adopting mechanisms for collecting large amounts of data. • The inability to hire specialised labour for data analysis and creating complex simulation models. • The inability to adopt specific tools and software.
	Data Collection	• The inability to develop and experiment with simulation models.
	Knowledge	• SMEs do not fully understand the level of complexity of their systems. • SMEs have knowledge gaps and lack in experience applying DES;
	Complexity	• SMEs are hesitant to apply technologies like simulations because they think they are time-consuming and complex.

Source: [4, 5, 7-9, 14, 16, 17].

Table I shows that DES, in its traditional format, presents some challenges for application at SMEs. According to [18], DES is usually seen as being a “hard” technique for Operations Research (OR). The assumption is that simulations must always exactly represent real systems, thereby requiring large amounts of accurate data. For [17], as either a “hard” or traditional paradigm, DES is linked to complex models requiring detailed data to provide objective analysis leading to optimal or good solutions.

Robinson [18] discusses that DES can also be used to support “soft” OR interventions, i.e., its main role is to provide understanding for a problem using a model that is not necessarily

precise but rather useful to the investigative process. According to Robinson, DES is a technique and not a methodology and can cross paradigms, i.e., it can be applied either as a "hard"/traditional or "soft" paradigm.

3. FACILITATED DES

The topic of facilitated modelling can be added to the issue of "hard" and "soft" OR. Facilitated modelling is an OR term that fits the definition and characteristics of "soft" OR methods [19]. According to Franco and Montibeller [19], the most common and traditional way for conducting OR studies is using the expert ("hard") mode, as the problem is entrusted to an OR consultant who creates a situation analysis model, solves this model to arrive at an optimal solution, and provides recommendations to the customer based on the results.

However, the expert mode may not be suitable in all situations. For example, there may be disagreement as to the situation, there are diverse stakeholders with distinct and even conflicting perspectives, objectives, values and interests, and someone needs to decide if the solutions derived from the analysis are desirable and viable for the company [19].

Facilitated modelling is a tool developed in the1980s as an alternative for conducting OR studies, as interventions are carried out together with the client. The problems are structured and defined to assess priorities and develop action plans for subsequent implementation [19]. This approach helps stakeholders gain confidence in the model and its results since they participate in the modelling process [20].

Several authors recognise that DES has great potential for use in its facilitated mode, and more studies should be carried out on this topic [17, 18, 20-25]. According to [17], researchers have been interested in uniting DES with facilitated modelling over the past decade. For [25], facilitated DES offers alternative ways of engaging with customers by involving a group of stakeholders in the simulation study.

According to [25], facilitated DES uses a simulation model in a workshop together with stakeholders to allow for subjective analysis of a situation by looking for desirable and viable solutions, considering the restrictions of the context of the application. Robinson et al. [17] argue that deeper stakeholders' involvement in simulation has advantages like improving information flows between stakeholders and modellers, creating better quality models, increasing the chances of reaching successful results, increasing the work's credibility, and increasing the probability that the results will be implemented.

Therefore, the objective of facilitated DES is to develop understanding/learning, generating a debate on a problem using a quick model that can be discarded at the end of the intervention [17]. According to the authors, the model is judged not so much for its accuracy but rather for its usefulness in promoting conversation and generating understanding of problems.

Some characteristics of facilitated DES are shown in Table II. This table also gives these characteristics compared to SME points from item 2.

Facilitated DES has the potential to be applied to SMEs, as seen in Table II. Therefore, a review current literature on facilitated DES frameworks was made to understand how it is applied, what the application contexts are, and what the results were. This review followed a transparent, step-by-step process to identify relevant literature in the field. The literature review used the following keywords: "Discrete event simulation" and "Facilitated modelling"; "Facilitation"; "Facilitated simulation modelling".

These keywords were searched in research databases platforms like Scopus, Science Direct, and the Web of Science. The following criteria were also included in each search. The terms should be present in the title, abstract and keywords of the article. Studies after 2001 were used since the oldest example of facilitated DES, reported in the literature, was published in that year [17, 18]. October 2021 was set as the cut-off date. Articles should have been published in full

by peer-reviewed scientific journals or from conference proceedings. Only articles written in English were used.

Table II: Comparison of facilitated DES and SME characteristics.

Facilitated DES	Characteristics and limitations of SMEs
Participatory approach: Includes the stakeholders in every simulation intervention, making exchanging knowledge direct. There are gains in confidence for stakeholders who use this technique, and knowledge is gained by applying and implementing the solutions, which is improved via participation in the project.	• The participatory approach makes managers feel included in decision-making since, according to [10], SMEs are characterised by central management. • Gives SMEs knowledge on DES, experience in applications, and results in them being less resistant to the tool. • Facilitates the flow of process information, given that according to [15], process information is held by the manager and key workers. • Facilitates implementing results via confidence in analysis, in the function of active participation.
It does not require detailed data collection, and estimates provided by stakeholders can be used.	Since it is challenging to convince managers about the effectiveness of new tools, existing data should be used [10], or estimates should be used. This is a quick way of getting DES in SMEs.
A model can be quickly created, not judged so much for its accuracy but rather for its usefulness in generating system understanding/learning and promoting conversation about problems.	This can soften the view of DES at SMEs since SMEs see DES as being time-consuming and complex [16]. Applications can happen quickly, creating a sensation of less complexity in applications. SMEs can benefit even from very simple models [16].
Provides stakeholders with satisfying solutions rather than optimal solutions.	• Since SMEs have financial constraints [13], this approach helps consider whether a solution is desirable and viable. • Focuses on simplicity and the generality of approaches [9].
Helps managers in decision-making	Provides a decision-making tool for SMEs characterised by decision-making based mainly on "intuition" or manager experience [9, 13].

Source: [17-20, 21, 23, 25].

Eighteen articles were found by applying these criteria, discounting redundancies. The screening stage included summaries, objectives, methods, and results for the 18 articles to select those that best fit the objectives of this review. Twelve articles were chosen for a full reading.

We observed that few articles on the subject are still being published, despite showing growth in publications over the years. We concluded that this theme is still incipient, and more work in this area is needed.

3.1 Critical analysis

This section presents a critical discussion on facilitated DES frameworks by analysing if they are adequate for meeting the needs of SMEs. Four different frameworks were identified in twelve articles and are presented in the following section.

a) Structure from [18]

Robinson (2001) [18] is the oldest article employing facilitated DES. This study analysed a user support service (helpline) at a university. The main problem was the bad reputation of the service, which had high average response times. The steps reported in this study were, defining the problem, setting the goals, making the conceptual model, developing the computer model, verifying it, validating it, facilitating it, presenting the results, giving recommendations, and implementing it. Although this structure led to improvements in the real system, it cannot be exactly replicated for SMEs. The authors did not detail their approach (how many days were spent, how long the meetings were, the tools to assist in facilitation, etc.). More structure is needed to inform the process, so SME managers can follow along with the entire process without feeling lost and so other researchers can replicate this in future studies.

b) SimLean Facilitate Framework

Robinson and other authors have deepened studies on facilitated DES and developed the SimLean approach [17, 21]. Robinson et al. [21] developed SimLean, an approach that unites DES and Lean principles, focusing on improving healthcare services.

SimLean Facilitate was employed as facilitated DES, and DES was used to transform a process map into a computer model. This took place during a lean event by rapidly developing a simple DES model using the process map. This model was used to understand better the system dynamics that involved stakeholders, facilitate exploring alternative ideas and identify potential improvements for the real system.

Despite SimLean Facilitate being more structured than [18], it still failed to present anything more detailed. The reported intervention took place over two full days, which is not feasible for SME employees since they cannot devote so much time to these activities given their tasks. This framework was designed for healthcare applications, which are different from SMEs. Therefore, this framework cannot yet be directly replicated in SMEs.

c) PartiSim Framework (Participative Simulation)

Of the 12 analysed articles, six were directly related to the PartiSim framework [24-29]. According to the literature, this framework is the most structured facilitated DES and offers sufficient guidance for novice modellers [24].

PartiSim Framework combines DES with soft system methodologies (SSM) to incorporate stakeholder engagement into lifecycle studies while being tailored to the goals of facilitated DES [24]. PartiSim comprises six main stages (1, 2, 3, 4, 5 and 6) and five sub-stages (1a, 2a, 3a, 4a and 5a), which were developed and tested at healthcare organisations [29].

Due to its many steps and sub-steps and long implementation period (6 months), PartiSim is complete but too complex for SMEs' direct application. The objective of SMEs should be quick interventions that generate useful results [10]. The computer model was more complex, similar to a traditional DES model, and was not simple. Consequently, detailed data collection not based on stakeholder estimates occurred. Regarding SMEs, the literature suggests working with existing data and avoiding detailed data collection since doing this would impede SME applications.

Even though PartiSim showed positive application results [28], the various stages, long application period, and need for detailed data collection impede direct applications at SMEs.

d) SIMTEGR8 Approach

SIMTEGR8 was presented by Tako et al. [30, 31]. This approach combines the two aforementioned frameworks (PartiSim and SimLean Facilitate), adapted to suit the evaluation process of an integrated health and social care service to ensure participation between service providers and users. SIMTEGR8 brought three groups of stakeholders together in the study.

This approach did not present details on applications to facilitate replicating the study. It was a very specific study on incorporating service users into the study. This approach does not fit SMEs since it would be challenging to gather SME customers for simulation studies. Thus, the simulation project would be help up by several factors, including volunteer participation. The objective of the SIMTEGR8 approach does not fit the SME context. Consequently, direct application at these companies is not possible.

e) Structure presented by Proudlove et al. [23]

Proudlove et al. [23] proposed a similar structure to PartiSim, but with a single difference. The authors developed all application stages (including the model coding step) in the presence of all stakeholders, which call fully-facilitated DES intervention.

However, this study did not present a closed structure with well-defined stages. They did not faithfully follow the structure in all cases, did not detail the steps, did not inform the types of tools used to support the process, and for more complex cases, they did not proceed with the

facilitated mode. Therefore, the study cannot be directly applied to SMEs, and adaptations are still needed.

Table III compares the aforementioned frameworks with the specific SMEs requirements. The "+" symbol indicates frameworks that partially address SME requirements. The "-" symbol indicates that the framework did not support the requirement. For the SIMTEGR8 approach, we noted that the objective did not fit the SME context since it had a different proposal for stakeholder involvement. This approach is not covered in Table III.

Table III: Comparison of frameworks with SME requirements.

Frameworks	**SME specific requirements**			
	FR	**DC**	**KN**	**CO**
Structure presented in [18]	+	+	-	+
SimLean Facilitate	+	+	-	+
PartiSim	-	-	+	-
SIMTEGR8				
Structure presented in [23]	-	-	-	-

Considering the problems related to financial limitations (item 2.1), structures that developed simple models and used estimated data from the main stakeholders received the "+" sign. Thus, structures presented in [18] and SimLean Facilitate developed simple models and used estimated data. PartiSim, and the structure from [23], developed complex models requiring detailed data collection. Proudlove et al. [23], despite proposing a simple solution, did not show successful results and had to abandon the fully-facilitated DES intervention.

All frameworks that proposed working with existing data or using estimates from the main stakeholders received the "+" sign for data collection (DC). Structure in [18] and SimLean used estimated data to feed the computer model. However, detailed data collection was required in PartiSim and in the structure of [23].

To attract the stakeholders during the intervention process, [11] state that SMEs require more descriptive, simple, easy-to-use frameworks. Therefore, detailed frameworks that explain how interventions will take place are better. The only framework that detailed how the intervention would occur was PartiSim, which presented a guide, manual, and tools. The other structures lacked more details. Therefore, PartiSim was the only one that received the "+" sign for Knowledge (KN).

Literature shows that the complexity of applying DES is related to data collection and preparation and developing the simulation model [4, 6]. Structures that built complex models and performed detailed data collections did not consider this SME requirement ([23] and PartiSim). The PartiSim framework conveyed an image of complexity even though it was very detailed. Fig. 1 graphically shows the frameworks that addressed SME requirements.

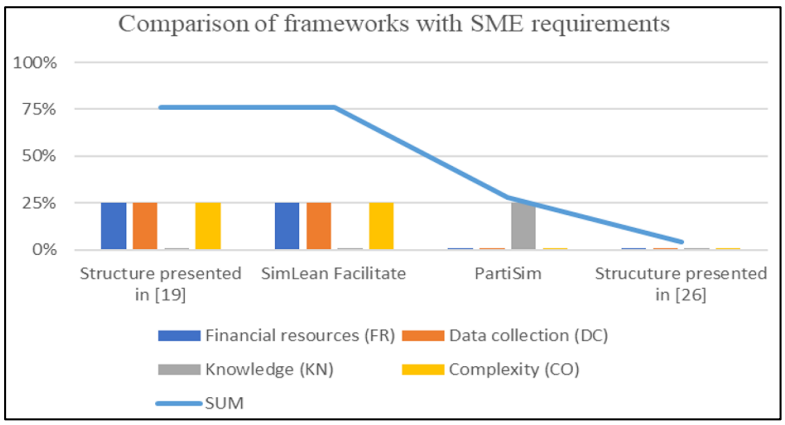

Figure 1: Graphic representation of the frameworks that addressed SME requirements.

In Fig. 1, each "+" sign from Table III received 25 %. So the Structure presented in [18] and SimLean Facilitate are the frameworks that most address the requirements of SMEs. Nonetheless, as per Table III and Fig. 1, no structure in this study considered all SME requirements. i.e., no framework evaluated in this study received the "+" sign for all SME requirements nor 100 % in Fig. 1. Therefore, these frameworks must be adapted for direct applications at SMEs and similar contexts.

Other impediments to applying these frameworks directly to SMEs are that practically all reported cases came from the healthcare sector. In other words, the structures were elaborated considering the characteristics of this context.

Finally, the global pandemic caused by the COVID-19 virus has made face-to-face meetings and site visits impossible. It would be interesting to consider virtual applications. According to [32], virtual meetings will only intensify in the coming years. This was not addressed in any of the studies.

Therefore, a framework that addresses all the specific SME requirements is still needed to expand DES studies at SMEs and similar contexts.

4. CONCLUSION

This paper presented the results of a critical analysis of the adequacy of facilitated DES frameworks in addressing the characteristics and limitations of SMEs. This article began by identifying the specific requirements for SMEs and then the difficulties of applying DES in its traditional form at SMEs. According to the literature, there are more studies on DES applications at larger companies than at smaller ones, given the specific requirements of SMEs (see Table I). One alternative is to apply facilitated DES (see Table II) to expand DES studies in these contexts.

The results showed that facilitated DES frameworks from literature cannot be directly applied to SMEs and are not suitable for the specific characteristics of these companies. Since the frameworks did not address all the specific SME characteristics, they cannot be applied at SMEs but rather at hospitals. They did not consider the effects of global pandemics or virtual communication resources.

We concluded that more studies need to be conducted on facilitated DES and applied SMEs, given the great potential of DES applications for SMEs and similar contexts. This study presents some essential recommendations for developing facilitated DES frameworks for applications at SMEs. SMEs' financial constraints should be accounted for by using existing data and creating simpler models. Stakeholders must be involved in every simulation project to gain trust and provide direct information exchanges between modellers and stakeholders. Applications must be fast and effective to generate real system improvements. Lastly, new ways of conducting facilitated DES online would innovate DES applications.

This article contributes to the literature by providing a basis for developing future studies on facilitated DES frameworks and encouraging more DES studies applied to SMEs and similar contexts to spread DES use among these companies.

As future research objectives, it is suggested the creation of a framework that considers the results raised in this article and performs applications in different contexts, such as industrial processes, reporting the differences between the applications. It is also suggested that this created framework consider how a virtual application of facilitated SED should be conducted online.

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REFERENCES

[1] Scheidegger, A. P. G.; Pereira, T. F.; de Oliveira, M. L. M.; Banerjee, A.; Montevechi, J. A. B. (2018). An introductory guide for hybrid simulation modelers on the primary simulation methods in industrial engineering identified through a systematic review of the literature, *Computers & Industrial Engineering*, Vol. 124, 474-492, doi:10.1016/j.cie.2018.07.046

[2] Mourtzis, D. (2020). Simulation in the design and operation of manufacturing systems: state of the art and new trends, *International Journal of Production Research*, Vol. 58, No. 7, 1927-1949, doi:10.1080/00207543.2019.1636321

[3] Amorim, G. A.; Lopes, L. A. S.; Silva Junior, O. S. (2020). Discrete event-based railway simulation model for eco-efficiency evaluation, *International Journal of Simulation Modelling*, Vol. 19, No. 3, 375-386, doi:10.2507/IJSIMM19-3-517

[4] Ivers, A. M.; Byrne, J.; Byrne, P. J. (2016). Analysis of SME data readiness: a simulation perspective, *Journal of Small Business and Enterprise Development*, Vol. 23, No. 1, 163-188, doi:10.1108/JSBED-03-2014-0046

[5] Byrne, J.; Liston, P.; Byrne, P. J. (2021). Analysis of complexity and simulation usage in manufacturing SMES, *Proceedings of the Operational Research Society Simulation Workshop 2021*, 267-276, doi:10.36819/SW21.029

[6] Byrne, J.; Byrne, P. J.; e Ferreira, D. C.; Ivers, A. M. (2013). Towards a cloud based SME data adapter for simulation modelling, *Proceedings of the 2013 Winter Simulations Conference*, 147-158, doi:10.1109/WSC.2013.6721415

[7] Liotta, G. (2012). Simulation of supply-chain networks: a source of innovation and competitive advantage for small and medium-sized enterprises, *Technology Innovation Management Review*, Vol. 2, No. 11, 13-20

[8] O'Kane, J.; Papadoukakis, A.; Hunter, D. (2007). Simulation usage in SMEs, *Journal of Small Business and Enterprise Development*, Vol. 14, No. 3, 514-527, doi:10.1108/14626000710773583

[9] Teerasoponpong, S.; Sopadang, A. (2021). A simulation-optimization approach for adaptive manufacturing capacity planning in small and medium-sized enterprises, *Expert Systems with Applications*, Vol. 168, Paper 114451, 13 pages, doi:10.1016/j.eswa.2020.114451

[10] Omri, N.; al Masry, Z.; Mairot, N.; Giampiccolo, S.; Zerhouni, N. (2020). Industrial data management strategy towards an SME-oriented PHM, *Journal of Manufacturing Systems*, Vol. 56, 23-36, doi:10.1016/j.jmsy.2020.04.002

[11] Löfving, M.; Säfsten, K.; Winroth, M. (2014). Manufacturing strategy frameworks suitable for SMEs, *Journal of Manufacturing Technology Management*, Vol. 25, No. 1, 7-26, doi:10.1108/JMTM-08-2012-0081

[12] Coleman, S.; Göb, R.; Manco, G.; Pievatolo, A.; Tort-Martorell, X.; Reis, M. S. (2016). How can SMEs benefit from big data? Challenges and a path forward, *Quality and Reliability Engineering International*, Vol. 32, No. 6, 2151-2164, doi:10.1002/qre.2008

[13] Mittal, S.; Khan, M. A.; Romero, D.; Wuest, T. (2018). A critical review of smart manufacturing & Industry 4.0 maturity models: implications for small and medium-sized enterprises (SMEs), *Journal of Manufacturing Systems*, Vol. 49, 194-214, doi:10.1016/j.jmsy.2018.10.005

[14] Hughes, R. W. C.; Scott, R.; Ridgway, K. (2012). Challenges of using discrete event simulation for facility planning in SMEs: a case study, *Proceedings of the 26th European Simulation and Modelling Conference*, 269-273

[15] Omri, N. O.; al Masry, Z.; Giampiccolo, S.; Mairot, N.; Zerhouni, N. (2019). Data management requirements for PHM implementation in SMEs, *2019 Prognostics and System Health Management Conference*, 232-238, doi:10.1109/PHM-Paris.2019.00046

[16] Hvolby, H.-H.; Svensson, C.; Steger-Jensen, K. (2012). Simulation of production setup changes in an SME, *Procedia Technology*, Vol. 5, 643-648, doi:10.1016/j.protcy.2012.09.071

[17] Robinson, S.; Worthington, C.; Burgess, N.; Radnor, Z. J. (2014). Facilitated modelling with discrete-event simulation: reality or myth?, *European Journal of Operational Research*, Vol. 234, No. 1, 231-240, doi:10.1016/j.ejor.2012.12.024

[18] Robinson, S. (2001). Soft with a hard centre: discrete-event simulation in facilitation, *Journal of the Operational Research Society*, Vol. 52, No. 8, 905-915, doi:10.1057/palgrave.jors.2601158

[19] Franco, L. A.; Montibeller, G. (2010). Facilitated modelling in operational research, *European Journal of Operational Research*, Vol. 205, No. 3, 489-500, doi:10.1016/j.ejor.2009.09.030
[20] Harper, A.; Mustafee, N.; Yearworth, M. (2021). Facets of trust in simulation studies, *European Journal of Operational Research*, Vol. 289, No. 1, 197-213, doi:10.1016/j.ejor.2020.06.043
[21] Robinson, S.; Radnor, Z. J.; Burgess, N.; Worthington, C. (2012). SimLean: utilising simulation in the implementation of lean in healthcare, *European Journal of Operational Research*, Vol. 219, No. 1, 188-197, doi:10.1016/j.ejor.2011.12.029
[22] Pessôa, L. A. M.; Lins, M. P. E.; da Silva, A. C. M.; Fiszman, R. (2015). Integrating soft and hard operational research to improve surgical centre management at a university hospital, *European Journal of Operational Research*, Vol. 245, No. 3, 851-861, doi:10.1016/j.ejor.2015.04.007
[23] Proudlove, N. C.; Bisogno, S.; Onggo, B. S. S.; Calabrese, A.; Ghiron, N. L. (2017). Towards fully-facilitated discrete event simulation modelling: addressing the model coding stage, *European Journal of Operational Research*, Vol. 263, No. 2, 583-595, doi:10.1016/j.ejor.2017.06.002
[24] Tako, A. A.; Kotiadis, K. (2015). PartiSim: a multi-methodology framework to support facilitated simulation modelling in healthcare, *European Journal of Operational Research*, Vol. 244, No. 2, 555-564, doi:10.1016/j.ejor.2015.01.046
[25] Kotiadis, K.; Tako, A. A. (2018). Facilitated post-model coding in discrete event simulation (DES): a case study in healthcare, *European Journal of Operational Research*, Vol. 266, No. 3, 1120-1133, doi:10.1016/j.ejor.2017.10.047
[26] Kotiadis, K.; Tako, A. A.; Vasilakis, C. (2014). A participative and facilitative conceptual modelling framework for discrete event simulation studies in healthcare, *Journal of the Operational Research Society*, Vol. 65, No. 2, 197-213, doi:10.1057/jors.2012.176
[27] Kotiadis, K.; Tako, A. A. (2016). A facilitation workshop for the implementation stage: a case study in health care, *Proceedings of the Operational Research Society Simulation Workshop 2016*, 165-174
[28] Kotiadis, K.; Tako, A. A. (2021). A tutorial on involving stakeholders in facilitated simulation studies, *Proceedings of the Operational Research Society Simulation Workshop 2021*, 42-56, doi:10.36819/SW21.005
[29] Tako, A. A.; Kotiadis, K. (2018). Participative simulation (PartiSim): a facilitated simulation approach for stakeholder engagement, *Proceedings of the 2018 Winter Simulation Conference*, 192-206, doi:10.1109/WSC.2018.8632434
[30] Tako, A. A.; Robinson, S.; Gogi, A.; Radnor, Z.; Davenport, C. (2019). Evaluating community-based integrated health and social care services: the SIMTEGR8 approach, *Proceedings of the 2019 Winter Simulation Conference*, 1220-1231, doi:10.1109/WSC40007.2019.9004874
[31] Tako, A. A.; Robinson, S.; Gogi, A.; Radnor, Z.; Davenport, C. (2021). Using facilitated simulation to evaluate integrated community-based health and social care services, *Proceedings of the Operational Research Society Simulation Workshop 2021*, 97-106, doi:10.36819/sw21.010
[32] Standaert, W.; Muylle, S.; Basu, A. (2021). Business meetings in a post-pandemic world: when and how to meet virtually?, *Business Horizons*, Vol. 65, No. 3, 267-275, doi:10.1016/j.bushor.2021.02.047