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Long Paper

Role of IoTs and Analytics in Efficient Sustainable Manufacturing of Consumer Electronics

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Abstract

Purpose – analytics has ushered in a new wave of changes in the manufacturer world. It presents manufacturing firms with efficient product manufacturing, personalization, and improvement in the way product is manufactured. However, debates arise in the implementation of these methods in some segments of the manufacturer, like electronic products, which are normally based on large-scale product manufacturing and prolonged supply chains (SC).

Method – Using examples set by pieces of literature to recognize different ways that enable TSM, the paper derives different useful techniques The study develops a conceptual framework to explore if analytics coupled with different product manufacturing consumer electronics (CE) can provide for a top-class sustainable (TSM) product manufacturing system. Through a purposive sampling of 419 consumer electronics manufacturer companies applying secondary and primary data, the study explored dynamic product manufacturing processes, the role of analytics, and its impact on TSM product manufacturing.

Results – The study discovers several uses of DM principles to evaluate the current product manufacturing processes worked for larger customer product CE by using analytics and industry analysis.
Conclusion – The evaluation's suggested framework mentioned in this research has a deeper impact on planning, and comprehension relationships, among factors of data analytics and TSM product manufacturing.

Recommendations – Usage of the Internet of Things (IoT) and analytics in a manufacturing system can significantly improve the efficiency and sustainability of manufacturing CE. Thus, manufacturers can greatly benefit by implementing these tools and should explore ways to do so.

Research Implications – The novel study has several implications, demonstrating how sustainable efficient manufacturing could be achieved using tools like IOTs and analytics.

Keywords – world-class, sustainable, manufacturing, analytics, IoT

INTRODUCTION

Recently, analytics has become an important subject matter of discussion among practitioners and academics. Asmussen, Jørgensen, and Møller (2021) expect that by 2028, the analytics requirements for the United States will increase by 3.5 folds and managers should have abilities to examine analytics for highly effective decision making. In manufacturing companies, analytics is the cutting edge of consideration among production experts in the USA. Predictive analytics and big data are driving factors for businesses to explore, using the possibility for meaningful and measurable impacts. On the flip side, researchers including Guan, Zhao, and Wang (2021) highlighted the impacts of analytics but were suspicious of its success. The literature on the role of analytics found advantages through its use, which include 12-25% increased return on investment, competitiveness, and productivity for the companies, financial surplus for clients, and educated decision making that permit exposure in operations and enhanced general performance measurement.

Most of the research has now endeavored to recognize the various implications of the idea and to record the likely good things about supply chain management. There are very few studies around the contribution of analytics to sustainability methods, and the role of analytics in obtaining renewable production, coming from a nation's perspective. "Top class manufacturing" was coined by Wang et al. (2021) denote "a group of methods, implying that the use of the greatest methods will lead to better performance. This practice-based method of community-type production has been echoed by several authors since then. In the study, top-class renewable production is described as a pair of methods that could lead to better sustainability efficiency. Kang et al. (2016) in the recent review of the role of analytics for sustainability, implies that "big data adoption has been sluggish to coalesce with sustainability

efforts", but they are centered on analytics and the environmentally friendly. In the existing papers, the contribution is to "big data analytics" and data in extending the literature on top-class sustainable manufacturing (TSM) and finding out how analytics could be used in various other areas.

Pushed with the importance of the additional role of analytics for TSM, the study functions to bridge this understanding gap by getting the following objectives: to make clear the meaning of analytics and the relationship of TSM; to suggest a conceptual framework that summarizes this role; to check the suggested sustainability framework, using information that will be heterogeneous, voluminous, diverse, and offers excessive velocity; to cultivate succeeding instructions on the role of analytics found TSM (Sahoo, 2021). Product manufacturing is dramatically dynamic, prompted by manufacturers and technologies technological methods. For manufacturing firms, future product manufacturing processes appear to progress past worldwide product manufacturing processes and remote product manufacturing plants to accept more, small-scale, and interconnected fast product manufacturing processes. Decision-makers now have new possibilities to restore or renovate product manufacturing abilities, which could strengthen flexibility, lower industry instabilities, and retain product manufacturing abilities.

The catalyst to move to a better-TSM product manufacturing horizon encompasses the need to improve longevity, goals to minimize risks and cost volatility, insecurities regarding transportation and energy expenses, and democratization of design and style, industry, and client proximity (Wang, Jiao, Wang, & Zhang, 2021). Additionally, large-scale personalization is now a viable model for various segments of the manufacturer. The problems established by dynamic customer requirements and policy changes, and the demand for new areas of expansion and improved profitability, establish a sense for rethinking the customer products product manufacturing process. Those entail exploring ways the current processes could be changed into more synchronized, regenerative, and sustainable ways of consumption and product manufacturing. Furthermore, there is an urge to think about the impact and possibility of new technology tools, like the internet, product manufacturing, and IoT.

The analysis discusses the consequent wide exploration hypothesis: How may analytics in TSM in the customer products segment? The analysis proposes a framework that theorizes the methods of analytics utilization that could condition manufacturing procedures. To use the framework, the analysis investigates altering manufacturing tasks in consumer electronics (CE), and the performance of analytics, in addition to the results in the division of manufacturing. The exploration includes data from thirty-seven companies produced from an interview. The analysis evaluates how analytics offers associated TSM and progress in manufacturing procedures. The significance of consumer electronics (CE) products identifies the role of ours against another systematic investigation of manufacturing engineering, which investigates production. In general, the exploration aims to enhance our understanding of the performance of analytics, provide a comprehensive understanding of the intricacy of TSM, and supply functioning acumen for suppliers.

LITERATURE REVIEW

There is a substantial feature of manufacturing, CE, output, transforming company techniques, and development in information. The analysis concentrates on TSM, manufacturing; procedures method, and analytics features in manufacturing. These three areas are probed. The analysis succeeding constructs the exploration stations to begin a theoretical framework. All the articles reviewed in the study were gathered from Google scholar.

IOTs and Analytics in Production

The next part evaluates the literature on TSM and analytics and identifies investigation areas. The study covers the contribution to literature and the limits on the efforts. They determine that the current literature surrounding Pcs has not focused much on decision manufacturing effectiveness. The hold-off in the info development by evaluation could therefore hinder the performance of manufacturing methods. Utilization of analytics may additionally improve the information bottlenecks, which affect MRP, and KANBAN. They argue that supply chain experts are bogged down with information, encouraging fresh means of considering the way information is generated, structured, and examined (Guan, Zhao, & Wang, 2021). Therefore, the volume, variety, and then velocity of information supply the groups with an impetus to follow and scale upward their uses.

The experts argue in the articles that quality information is essential to looking at today's supply chain procedures, using organizational theories (Bashar, 2019). Kozjek (2020) argued that big data and social media are complementary during the existing scenario. They additionally observed that the area of functions control remains quite sluggish in examining social media and analytics. This author provides a conceptual framework associated with the use of Facebook to learn current trends in SCM. Kumar et al. (2020) continue to talk about the prospective use of analytics in merchandise life cycle control. The ramifications of analytics for top-class production, and its extension from a sustainability perspective, have not but been discovered.

Top-class Sustainable MANUFACTURING

Moyne and Iskandar (Moyne & Iskandar, 2017) have connected TSM to the methods which wish during allowing better performance. Since 2015, Groggert's (2017) works with TSM have attracted huge interest, coming from practitioners and academia. He argued that all those production groups regularly carried out around terminology of better industry efficiency have adopted 5 typical methods - just-in-period, simplicity, employee involvement, total productive maintenance, and quality management. Weich et al. (2022) have even recognized typical methods among production groups as complete quality, people involvement, and JIT. Zdravković, Panetto, and Weichhart (2022) stated production methods as complete quality, lean manufacturing/operations, customer focus, supplier relations, incorporated production

and services, and distribution after product sales. Raut et al. (2021) identified methods in which individual companies coming from conventional production groups complete quality, lean operations, employee involvement, supplier relationship, prosperous group, and maintenance technologies.

Worker participation

Based on Bashar (2019) worker participation, production vision and strategy, innovation, and performance measurement will be the methods that would be a production business. Shao, Shin, and Jain (2014) have reported that good managing determination, client connection, provider connection, role power managing, role perceptions, item design and style procedure, statistical management and responses, and process flow managing, will be the several components that explain the regular functionality on the production groups. Sahoo (Sahoo, 2021) has determined that worker participation, production approach, and small business technique, are distinct production groups coming from conventional production groups. Shao et al., (Shao, Shin, & Jain, 2014) have determined methods of TSM, such as production technique, leadership, environmentally friendly production, a man learning resource managing, supply managing, provide chain managing, buyer connection managing, manufacturing preparation, total productive maintenance, total quality management and lean production (Groggert, 2017).

The emphasis of TSM on client satisfaction via fulfilling the correct functionality goals claims the benefits of obtaining, keeping, and considering analytics for, choice-making, originality, presence, modification of services and products, and eventually lasting competitive advantage (Raut, et al., 2021). In addition, mirroring the necessity conveyed by businesses to attain exceptional functionality, but when you consider simultaneously the social and environmental effects of their endeavors, we spotlight the benefits of analytics for renewable TSM, which is talked about in the following portion.

Sustainable Manufacturing Practices

Renewable production is a method of advancement of new products. It is identified through the U.S. Division of Commerce as the construction of fabricated items that employ tasks that lessen damaging green impacts, help save natural resources and energy, are not harmful to workers, towns, and customers, and therefore are economically sound (Guan, Zhao, & Wang, 2021). The integration of demands across the entire lifetime of merchandise demands a completely new means of new decision tools and thinking to become utilized. Hence renewable production requires eco-friendly item layout, green technology, green procurement, and purple manufacturing (Sahoo, 2021). Production methods have developed over the last two years through conventional production, focused on price, quality, flexibility, and delivery to renewable production. This is designed to achieve a sense of balance between green, economic, and social length and width to fulfill stakeholders and realize competitive advantage (Moyne & Iskandar, 2017).

Groggert (2017) has argued that technologies, training, cultural track record, and accountability tend to be the primary enablers of renewable production. Kang et al., (Kang, et al., 2016) have argued that the minimization of electrical power use, and squander minimization, are two important areas of renewable production. Shao, Shin, and Jain (2014) have argued that functional approaches, strategies, and operational policies and techniques are the basis of renewable production. Kumar Sangaiah et al., (Kumar Sangaiah, Chaudhary, Tsai, Wang, & Mercaldo, 2020)has additionally argued that to carry out renewable production, a business must focus on crucial enablers like overseas problems, fashionable problems, revolutionary items, reconfigurable production methods, agile manufacturing, lean production, complexity analysis, flexible organization, and performance measurement. Guan et al., (Guan, Zhao, & Wang, 2021) have additionally attempted to grab the renewable production habits to the world category renewable production amount. The pillars selected are leadership, supplier relationship management, regulatory pressures, employee participation, agile manufacturing, lean production, and reconfigurable manufacturing systems.

Research Gap

Regardless of the increasing fascination with TSM, there's always not enough opinion waring existing literature regarding its implication and definition for businesses. Furthermore, most studies have investigated problems such as performance, functional techniques, and strategies to attain competitive advantage (Asmusse et al., 2021). Even though the above-mentioned scholars realize the demand for analytics in TSM, there's still investigation to be carried out to deal with the role of analytics. Current research has examined how companies might safety belt the advantages of analytics for production, hinting those analytics are essential to this technique. Nevertheless, they have primarily centered on value' instead of on variety, velocity, and volume. Additionally, they do not concentrate on the role of analytics on TSM. We try to deal with the spaces and therefore are pushed to learn renewable production not just in Europe, but also on a worldwide fitness level to deal with the problems associated

RESEARCH METHOD

We suggest a framework to look at the benefits of analytics for TSM. We have determined the constructs that affect renewable production on the foundation of comprehensive literature evaluation and then primary part evaluation over the pair of information gathered up. The foundations of our theoretical framework of ours are seated with the information we have gathered.

Figure one shows how data analytics can use data from manufacturing firms in real-time to conduct different kinds of analytics like descriptive, prescriptive, diagnostic, and predictive analysis in real-time, allowing managers with insights to improve operations in the

manufacturing facility. Sustainable manufacturing configuration, as noted in figure 1, is dependent on the insights received from analytics. Hence, insights generation is very crucial in this process to allow optimized configuration for efficient manufacturing.

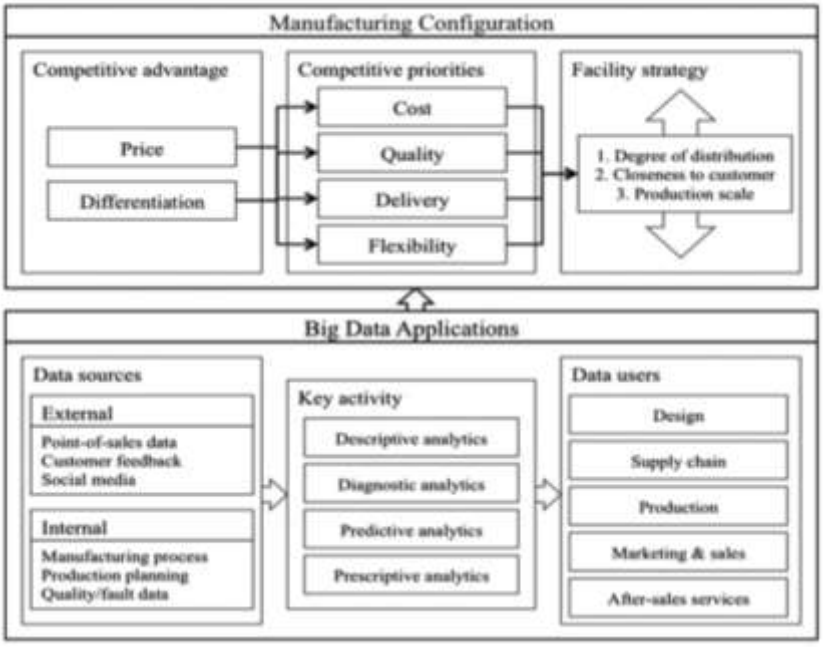

Figure 1. The real-time usage of data in manufacturing

In Figure 2, the constructs are represented as X1, X2, X3, X4,…., and Xn represents orthogonal factors which we have derived using suitable data reduction methods, as discussed later. We argue the constructs are further and formative, they've reflective dynamics. Each one of the constructs is analyzed by having an analytics viewpoint, which is talked about in our research design section.

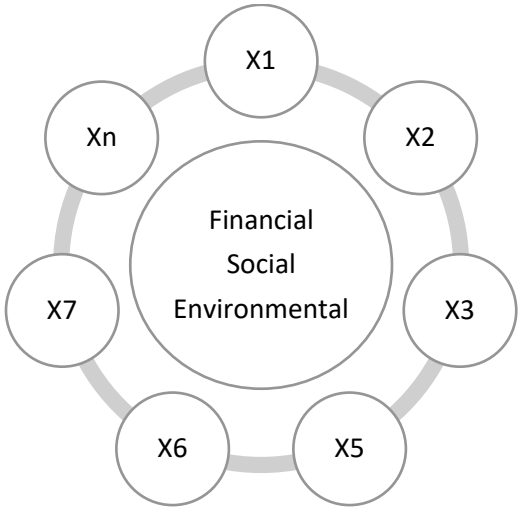

Figure 2. Analytics and efficient TSM framework

RESEARCH DESIGN

Measures

Actions have been implemented or even customized of scales determined against extant literature to stay away from weighing machine proliferation. We applied multi-item steps of constructs for our theoretical model of ours so that we can boost dependability, lessen measurement errors, guarantee better variability among survey people, and boost validity (Groggert, 2017). Each construct was operationalized utilizing a minimum of three signs for good analysis and measurement, putting on confirmatory component evaluation. Most signs bundled in the survey had been pretested to confirm the exact operationalization of outlined variables in the survey instrument.

Sampling Design

We identified big production companies with more than a thousand workers and a yearly turnover of more than two billion USD. The original test frame was composed of 1130 production companies and was put together from directories supplied by the Institute of Manufacturing.

Data Collection

Information was gathered via social media websites. Kozjek (2020) has argued that APIs could help gather information from social networking in an honest way. SNS has finally turned out to be rising essential for information researchers. Just before wondering, respondents have been informed that replies will be held purely confidential. We sent our questionnaire of ours to these respondents, who acknowledged our request on LinkedIn or Facebook to reply to our survey of ours. In this approach, we might get to the optimum lots of respondents in a few days in deep comparability to standard strategies including e-mail, in which respondents might not react to the e-mail, or even instantly delete it or perhaps make it spam.

We incorporated LinkedIn, Twitter, and Facebook. They had been selected since the result is comparatively quickly inside comparability to conventional details compilation methods. A wide array was permitted, the amount, veracity, the authenticity of the information can be examined that conventional details compilation does not provide. General, we got 290 comprehensive and functional replies. We followed in place with various respondents, and monthly we got an additional 129 comprehensive and functional replies. In this manner, we got 419 comprehensive and functional replies, and they stand for 38.74 %. The result dimensions are very loaded with comparability to identical scientific studies done in the OM/SCM area utilizing conventional details compilation techniques. Table one displays the market profile of the respondents.

Table 1. Profile of responders

		Number of respondents	Percentage of respondents
Designation	Vice President	105	25.1%
	General Managers	88	21.0%
	Managers	111	26.5%
	Deputy Managers	115	27.4%
Experience(years)	Above 20	180	43.0%
	15–20	55	13.1%
	10–14	30	7.2%
	5–9	55	13.1%
	0-4	99	23.6%
Business in existence (years)	>20	198	47.3%
	15-20	108	25.8%
	10–14	74	17.7%
	5–9	38	9.1%
	0-4	1	0.2%

In Table one, we can realize that around forty-five % of respondents are in senior jobs in their companies. This might explain why getting close to the respondents using social networking sites (SNS) has a much better effect on the comparability to mailing e-mail, and following upwards many times for reaction. More than two-thirds of the employees had been with the company for more than 10 years. Interestingly, almost half of the businesses interviewed had been in existence for more than twenty years.

Testing of analytics

Kozjek et al. (2020) argued that analytics have special qualities. We have gathered information coming, thus our gathered information might have higher amounts and bunches, though tests are necessary to deal with attainable difficulties during information evaluation, for example, heterogeneity, spurious correlation, noise accumulation, and incidental endogeneity. We cover their assessment of theirs in the coming areas.

Heterogeneity

Analytics from information buildup out of different several energy supplies corresponding to various subpopulations. Kozjek et al. (Kozjek, 2020) have argued that the subpopulations might display a few special qualities not discussed by others. Just in case of standard details

sets in which test size is moderate or small, information points by using little subpopulations are known as outliers, and the outliers might influence the last results of statistical analyses. Nevertheless, in analytics, the test dimensions have the relative advantage of conditions of exploiting heterogeneity in a beneficial method to recognize the connection between specific covariates and unusual results, such as unexpected decrease or increase in profitability or market share of the business and finding out how renewable methods used by the businesses can enable them to do much better compared to their competitors. We show the combination type with the population as:

$$\mu_1 p_1 (y;\ \theta_1(x)) + \ldots\ldots\ldots\ldots\ldots\ldots + \mu_m p_m (y; \theta_m(x)) \ldots\ldots\ldots\ldots\ldots\ldots \quad Equation\ 1$$

wherever μj ≥ 0 belongs to the proportion on the jth subpopulation p j and) could be the likelihood division on the result of the jth subpopulation because of the covariates x with θj because the parameter vector (Dubey, Gunasekaran, Childe, Wamba, & Papadopoulos, 2016). In truth, numerous subpopulations hardly ever are present, i.e. μj is extremely little, which makes it impossible to infer the covariates dependent details θj because of not enough info. However, in analytics because of big test sizing, the test sizing n*μj with the jth subpopulation is usually reasonably big, regardless of whether μj is incredibly little. This allows us to infer roughly the subpopulation parameter θj.

Apart from the above-mentioned benefits, the heterogeneity of analytics could also present considerable issues as much as statistical inference. Thus, to bring an inference from combination type as revealed around situation one for big datasets requires advanced statistical and computational procedures. Shao et al. (Shao, Shin, & Jain, 2014) argued that in the event of lower length and width, regular methods, including expectation maximization in the event of a combination version, might be put on efficiently.

Some authors (Bashar, 2019) have mentioned that in the event of higher length and width, we must become cautious while estimating details to stay away from more than suiting or maybe racket accumulations. From our case of ours, we have established the heterogeneity by using Sahoo' (Sahoo, 2021) situation I^2= (Q-df)/Q)*100 %, in which Q provides chi-squared df, and statistics symbolize amounts of independence. In our situation, the I^2 great gotten is over 90%. Thus, we can determine that there is a lot of heterogeneity in our dataset of ours. However, heterogeneity for a dataset was argued in the past as a limitation due to several factors, including compromise with external and internal validity. The way we argue that in a deep history of analytics, heterogeneity could help check out fascinating observations that were not checked out with conventional datasets. Thus, we imagine that a great computation algorithm must be created.

Correlation

Just in the case of analytics, the big dimensionality leads to spurious correlation, talking about the reality that many uncorrelated arbitrary variables have higher test correlations in

huge length and width. Thus, if spurious correlations weren't correctly looked after, it could lead to wrong statistical inferences and false scientific discoveries, as argued by Asmussen et al., (Asmussen, Jørgensen, & Møller, 2021). Thinking about the issue of estimating the coefficient vector β associated with a linear design

$$Y=X*\beta + \in, \text{Var}(\in)= \sigma^2 Id \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad \textit{Equation 2}$$

Where $Y \in Rn$ symbolizes result vector $X= [X1, X2, X3,...., Xn]T \in R^{n*d}$ belongs to the style matrix, $\in Rn$ presents an unbiased arbitrary racket vector, and Id would be the d*d identity matrix. In addition to adjustable choice, a spurious correlation could lead to incorrect statistical inference (Dubey, Gunasekaran, Childe, Wamba, & Papadopoulos, 2016). This may be defined by a linear equation.

Dimension Reduction and Random Projection

Bashar (Bashar, 2019) argued that information minimization while using the most widely used method is demanding. When projecting information matrix D for this linear subspace, which to get as information matrix. This treatment is ideal among all linear projection techniques in reducing the squared mistake created by projection. Doing the Eugene area decomposition over the test covariance matrix is a computational struggle when all d and n are big. The computational intricacy is o, and that isn't doable in the event of big datasets. Thus, in that situation, "random projection" is suggested for information minimization. However, in our case, because of restricted test sizing, we utilized equal methods, and the last effect was not distinct. Thus, we have proceeded with the PCA result. However, just in case of big details sets after that, RP will be the greater method of comparability to PCA.

DATA ANALYSIS AND FINDINGS

In this section, we will discuss the qualities of analytics, and evaluate research hypotheses.

Assessment of statistical properties

We carried out assessments based on the assumptions of continuous variance, presence of outliers, and normality of gathered information to ensure that the information could be used for tests. We applied plots of residuals by expected values, rankings, a plot of statistics, and residuals of kurtosis and skewness. To identify multivariate outliers, we applied ranges of expected variables. The skewness is discovered to be just less than two, and the maximum absolute value of kurtosis is discovered to be under five, which is generally inappropriate limitations. To ensure that multicollinearity was not an issue, we calculated variance. All VIFs were under 1.5 and, consequently substantially less than the suggested threshold of 10.0, hinting that multicollinearity was not an issue. We utilized confirmatory component evaluation to build convergent validity and one-dimensionality of elements.

Table 2: Scales and statistical components

X	Elements	Alpha	Loadings, λi	SCR*	AVE
X1	Management	0.68	0.71	0.75	0.55
X2	Regulation	0.63	0.66	0.72	0.57
X3	Supplier	0.69	0.70	0.74	0.59
X4	Employee	0.62	0.62	0.69	0.56
X5	Customer	0.56	0.65	0.72	0.56
X6	Quality	0.51	0.65	0.72	0.55
X7	Productive	0.66	0.68	0.73	0.55
X8	Lean	0.54	0.61	0.69	0.45
Y1	Environmental	0.63	0.68	0.68	0.49
Y2	Social	0.56	0.68	0.68	0.52
Y3	Economic	0.70	0.58	0.67	0.51

From Table two, we can realize that every weighing machine offers SCR>0.68 and AVE>0.45 which is over the threshold proposed for every construct. The found importance of λi > 0.5. The value is more compared to the threshold value of every component, which comprises a construct of framework revealed in Figure two. For that reason, we can think that convergent validity prevails in our framework.

CONCLUSION AND FURTHER RESEARCH

In the paper, we have attempted to revisit the role of analytics on TSM by using analytics, recognized by volume, variety, veracity, and velocity. The study provides an enormous literature on sustainable manufacturing. We have created a theoretical framework utilizing a substantial literature overview of existing literature, and even further analyzed the theoretical framework, using gathered information. We have examined the psychometric qualities of measurement products of our instrument of ours. The result indicates that our framework constructs offer convergent validity and discriminant validity. Hence, our constructs gratify article validity and construct validity.

Academic and managerial contribution

This research plays a role in the literature on top-class sustainable manufacturing. We mentioned the benefits of analytics through the suggested framework, pushed by the necessity conveyed by scholars to use analytics to attain exceptional functionality based on the principles of TSM, but simultaneously to think of the social and environmental effects of these organizational steps (Kang, et al., 2016). The study adds sustainable practices and sustainable manufacturing, dealing with the necessity conveyed by Kang et al., (Kang, et al., 2016) to do analytics associated with the green, community, and financial ramifications of TSM.

Our research is novel as it suggests a method new to the industry. The study does not just focus on the dimension of 'value'. Instead, we use 'volume', 'variety', 'velocity', and 'veracity' (Raut, et al., 2021). Finally, the paper stretches scientific studies that focus on functional techniques and strategies to achieve competitive advantage by showing the role of analytics. We found TSM through a considerable literature evaluation, by what distinct variables are extracted, analyzed, and evaluated, creating a framework that denotes the role of analytics inside TSM.

Our results offer helpful courses for knowledge, in that it claims the role of analytics in TSM is to achieve exceptional financial, community, and environmentally friendly results, by focusing on the elements extrapolated from our framework (Sahoo, 2021). In addition, it spotlights the role of analytics as a driver of TSM methods belonging to developed economies. These days green revolution has brought on the demand for renewable methods, but exactly the study aims to achieve better functionality, as highlighted by TSM. Managers may also use the framework we recommend guidelines to look at the elements vital to attain TSM by using analytics.

Limitations and Further Research Directions

The present study of ours has its limitations. For starters, we have attempted to gather information from a limited source. The test dimensions might have to be enhanced. Next, the information is gathered using an organized questionnaire. The analyses of the information will already be complicated if we had gathered information using various methods. Subsequently, the heterogeneity might have posited several completely different degrees of a task. We argue the heterogeneity challenge: it will have presented us with several chances to check out the microstructure with more information than in the existing situation. Information minimization has presented us with a sufficient chance to determine a lot more enablers of TSM. Evaluating the most effective constituent of the analytics ability for enhanced performance must be part of upcoming investigation instructions. Previous scientific studies proposed that competitive advantage is attained throughout the firm's potential to deploy and use distinct, invaluable, and inimitable energy and abilities.

REFERENCES

Asmussen, C. B., Jørgensen, S. L., & Møller, C. (2021). Design and deployment of an analytic artefact – investigating mechanisms for integrating analytics and manufacturing execution system. *Enterprise Information Systems*, 1-30. doi:https://doi.org/10.1080/17517575.2021.1905881

Bashar, A. (2019). Intelligent development of big data analytics for manufacturing industry in cloud computing. *Journal of Ubiquitous Computing and Communication Technologies, 01*(01), 13-22. doi:https://doi.org/10.36548/jucct.2019.1.002

Groggert, S. W. (2017). Status quo and future potential of manufacturing data analytics—an

empirical study. *Industrial Engineering and Engineering Management (IEEM)* (pp. 779-783). IEEE. doi:10.1109/IEEM.2017.8289997

Guan, Z., Zhao, Y., & Wang, X. (2021). Design pragmatic method to low-carbon economy visualisation in enterprise systems based on big data. *Enterprise Information Systems*, 1-24. doi:https://doi.org/10.1080/17517575.2021.1898049

Kang, H. S., Lee, J. Y., Choi, S., Kim, H., Park, J. H., Son, J. Y., & Noh, S. D. (2016). Smart manufacturing: Past research, present findings, and future directions. *International Journal of Precision Engineering and Manufacturing-Green Technology, 3*(1), 111-128. doi:https://doi.org/10.1007/s40684-016-0015-5

Kozjek, D. V. (2020). Advancing manufacturing systems with big-data analytics: A conceptual framework. *International Journal of Computer Integrated Manufacturing, 33*(2), 169-188. doi:https://doi.org/10.1080/0951192X.2020.1718765

Kumar Sangaiah, A., Chaudhary, A., Tsai, C., Wang, J., & Mercaldo, F. (2020). Cognitive computing for big data systems over Internet of Things for enterprise information systems. *Enterprise Information Systems, 14*((9-10)), 1233-1237. doi:https://doi.org/10.1080/17517575.2020.1814422

Kusiak, A. (2017). Smart manufacturing must embrace big data. *Nature*, 23-25.

Moyne, J., & Iskandar, J. (2017). Big Data Analytics for Smart Manufacturing: Case Studies in Semiconductor Manufacturing. *Processes, 5*(3). doi:https://doi.org/10.3390/pr5030039

Raut, R., Narwane, V., Mangla, S. K., Yadav, V. S., Narkhede, B. E., & Luthra, S. (2021). Unlocking causal relations of barriers to big data analytics in manufacturing firms. *Industrial Management & Data Systems, 121*(9). doi:https://doi.org/10.1108/IMDS-02-2020-0066

Sahoo, S. (2021). Big data analytics in manufacturing: a bibliometric analysis of research in the field of business management. *International Journal of Production Research*, 1-29. doi:https://doi.org/10.1080/00207543.2021.1919333

Shao, G., Shin, S. J., & Jain, S. (2014). Data analytics using simulation for smart manufacturing. *Winter Simulation Conference* (pp. 2192-2203). IEEE. doi:10.1109/WSC.2014.7020063

Wang, Q., Jiao, W., Wang, P., & Zhang, Y. (2021). A tutorial on deep learning-based data analytics in manufacturing through a welding case study. *Journal of Manufacturing Processes, 63*, 2-13. doi:https://doi.org/10.1016/j.jmapro.2020.04.044

Wiech, M., Boffelli, A., Elbe, C., Carminati, P., Friedli, T., & Kalchschmidt, M. (2022). Implementation of big data analytics and Manufacturing Execution Systems: an empirical analysis in German-speaking countries. *Production Planning & Control, 33*((2-3)), 261-276. doi:https://doi.org/10.1080/09537287.2020.1810766

Zaki, M., Theodoulidis, B., Shapira, P., Neely, A., & Tepel, M. F. (2019). Redistributed Manufacturing and the Impact of big data: a consumer goods perspective. *Production Planning & Control, 30*(7). doi:https://doi.org/10.1080/09537287.2018.1540068

Zdravković, M., Panetto, H., & Weichhart, G. (2022). AI-enabled Enterprise Information

Systems for Manufacturing. *Enterprise Information Systems, 16*(2), 668-720. doi:https://doi.org/10.1080/17517575.2021.1941275