Post-Pandemic Insights: Evaluating the Impact of Big Data Analytics, Circular Economy Practices, and Digital Marketing on Firm Performance

Saad Rafi[1] , & Muhammad Sulman[2]

[1]Department Finance and Business Analytics, Mercer University, Atlanta Campus, Georgia
[2]Department of Management Science, BPP University, UK
[*]Corresponding Author: Saad Rafi. Email: sadi.rafi@gmail.com

Abstract: The COVID-19 pandemic has caused significant disruption to global economies, disrupting business activities, consumer behaviour and supply chain dynamics. Keep in view these issues, employing business data analytics (BDA), circular economy (CE), and digital marketing has become critical for businesses to stay growing and agile. The study explores the impact of BDA on CE and digital marketing and their impact in enhancing resilience and sustainability performance of China's manufacturing sector during the post-pandemic era. Via cross-sectional data and the PLS-SEM (partial least squares structural equation) modelling, the findings validates that BDA implementation augments decision-making, while CE contributes to environmental impact mitigation and cost reduction. The findings also elucidate that collective focus on digital marketing, driven by changing consumer preferences, is driving customer engagement and boosting financial performance. This research suggests policy makers to invest in BDA and data driven stagies to get enrich insight about market trends and real time data, customer preference and manage SC disruption in post pandemic era.

1. Introduction

The COVID-19 pandemic has been an exceptional global crisis, disturbing outdated business practices, consumer behaviors and supply chains [1]. It exposed weaknesses in traditional business models and forced organizations to adapt according to ever changing market demand [2]. Manufacturing, aviation, and tourism were among the hardest hit, facing restrictions, labour shortages, and supply chain disruptions [3]. However, despite these major challenges, the pandemic has accelerated the adoption of digital transformation and sustainable practices.

In today post pandemic era, digital tools like BDA, CE models, and digital marketing become key supporters for businesses in managing uncertainties [4]. Big data analytics (BDA) can provide insights that would help businesses cope with supply chain disruptions, possibly optimise inventory, and even predict market trends [5]. The practices of CE alleviate resource scarcity and bring business operations in line with sustainability goals [6]. Establishing CE practices help companies overcome current environmental obstacles and improve business performance [8]. At the same time, as businesses were forced to shift their operations online, digital marketing became a necessary tool for engaging customers remotely and encouraging purchases in an increasingly digital world [7].

However, it is unclear how a firm's internal capabilities affect its overall accomplishment [9,10]. Very few research has been conducted on the impact of BDA and digital marketing on firm performance [11, 12]. This study explores how CE, BDA and digital marketing can reduce supply chain ambiguity and improve firm performance in

post pandemic. This study also addresses insights into how these tools and practices integrate to create resilience, escalate effective efficiency, and promote sustainability, with a focus on Chinese manufacturing companies.

The main contributions part of the article are based on the above discussion as follows.

- Explores how BDA, CE practices, and digital marketing can drive value creation for firms and improve performance in the post-pandemic era.
- Fills a gap in the literature regarding the regional application of these practices by providing empirical insights from Chinese manufacturing firms.
- Using CB-SEM for modelling complex relationships among variables.
- Emphasizes actionable tactics that companies can adopt to utilize digital tools and sustainability practices for enhanced operational efficiency, customer engagement and overall resilience.
- Policy implications to enable the adoption of digital transformation tools and sustainability initiatives in the sector.
- Provides unique insights into how companies can navigate uncertainty and grow performance post-global crisis.

Following is the organization of this research. first section indicates the introduction followed by review of literature. While, third and fourth section elucidate the methodology, result and discussions. Last section indicate the conclusion and policy relevance.

2. Literature Review

2.1 Digital marketing, BDA, and Post COVID-19

The value of BDA is becoming increasingly apparent as organizations recognize its role in augmenting decision-making competencies and addressing operating ineptitudes [13]. Throughout the COVID-19 pandemic, BDA tools have played a vital role in addressing issues such as supply and demand imbalances, reforming production planning, and refining logistics management [14]. For instance, companies employ predictive analytics to forecast market trends, diminish the risk of out-of-stock, and evade overproduction [15]. In addition, progressive capabilities such as machine learning, cloud computing and deep learning processes empower companies to route large amounts of data samples, classify hidden patterns, enable data security and make real-time strategic amendments [16] [25] [17] [31].

Likewise, the epidemic provoked a motivation concerning digital marketing because of parameters on travel, which enforced companies to practice online platforms to fulfil the ever-changing weights of businesses. Numerous studies also accentuated the prominence of data-driven marketing approaches and their positive impression on customer and commercial enactment [18]. The application of BDA to digital marketing has enhanced the efficacy of implements, i.e., targeted ad campaigns, modified content, and real-time analytics [19]. For illustration, analytics-based insights permit businesses to modify products and services based on the individual prerequisites of customers with the help of their interests, online behavior and online activities. This personalized technique surges customer satisfaction although also resulting in more revenue being created.

CE procedures highlight sustainable resource usage through reutilizing, reuse, and waste treatment [6]. Disturbances to global supply chains because of the pandemic tinted the assistances of CE models to effortlessly encounter resource necessities through diminishing reliance on the unoriginal linear procedure that has been protracted for centuries [20][21]. CE practices utilize digital technologies such as blockchain and the Internet of Things (IoT) to improve supply chain transparency and facilitate sustainable resource management [3]. CE models have been shown to reduce operating costs, increase resource efficiency, and improve brand reputation in a way that supports global sustainability targets and makes businesses front-runners in terms of environmental accountability [22][43].

The combination of BDA, digital marketing and CE practices has become vibrant in a world where the repercussion of a pandemic can still be felt. BDA pursue CE practices through optimizing resource allocation, and waste management while digital marketing facilitates market outreach increasingly aimed at sustainably designed products. Collectively, these tools enhance the performance potential and resilience of the firm and contribute to its sustainable, data-driven operation [23] [24].

- H1: Post-pandemic era increased the use of BDA technologies
- H2: The post-pandemic era has positively impacted the utilization of digital marketing.
- H3: CE practices have gained prominence in the post-pandemic era.

2.2 Firm performance

Industries are under a lot of pressure to apply green production methods as a result of the fast pace of industrialization [29]. In the post-pandemic era, businesses has advanced their financial and environmental performance and competently achieve their industrial operations by implementing AI, BDA, IoT, and smart sensors [30]. These technologies enable companies to address product shortages, reduce waste, and improve resilience in their operations, supporting sustainable business performance [32]. The pandemic-driven shift to remote work has left a lasting impact on organizational practices [33]. Remote work has not only reduced water, energy, fuel, and waste consumption in offices and vehicles but has also encouraged the adoption of continuous learning and digital collaboration tools. These practices have enhanced operational efficiency and contributed to improved business outcomes in the post-pandemic era [34][35].

Digital marketing strategies have also become integral to business models in the aftermath of the pandemic. For example, Italian retail companies began selling their goods online during pandemic, which improved their financial enactment [36]. Restaurants have also started introducing online food ordering systems; however, this system did not guarantee a hundred per cent increase in sales, but it allowed restaurants to improve their operational processes [37]. Companies around the world have also adopted a "shared store" that helps companies manage the delivery of their products and improve their performance [38] has gained momentum in the post-pandemic landscape. These practices have allowed companies to streamline logistics, improve customer satisfaction, and enhance overall performance, demonstrating the critical role of technology and digital transformation in navigating the challenges and opportunities of the post-pandemic era.

Based on the above description, hence we hypothesize as below:

H4: There is a significant positive relationship between the adoption of BDA and the firm performance.

H5: BDA has positive impact on digital marketing.

H6: Digital marketing has a positive and significant impact on firm performance.

H7: CE practices improve firms' performance.

3. Research Methodology

This research used a cross-sectional survey to collect data from supply chain managers and executives working in Chinese manufacturing companies. Participants were asked to complete a structured questionnaire designed using a five-point Likert scale to measure the effects of BDA, CE practices, and digital marketing on business performance. Of the 347 questionnaires distributed, 293 were completed fully and included in the analysis, 54 with incomplete submissions were excluded.

The study used CB-SEM to survey the relationships between the variables. This methodology was designated due to its efficacy in handling latent variables and complex models. To evaluate the model's fit, numerous metrics were used, including the Goodness-of-Fit Index (GFI), Root Mean Square Error of Approximation (RMSEA and Normed Fit Index (NFI). All of these indicators surpassed or reached the suggested criteria, guaranteeing the consistency of the model as exposed in Table. 1.

Table 1 Model Fit Indices

Metric	Value	Threshold
RMSEA	0.047	<0.08
GFI	0.920	>0.90
NFI	0.931	>0.90

3.3 Sample Profile

The research participants comprised supply chain managers, operations executives, and marketing experts representing a variety of small to enormous manufacturing corporations across China. This diversified sample presented a wide-ranging perspective on industry practices, proposing valued insights about the adoption of BDA, digital marketing and CE procedures.
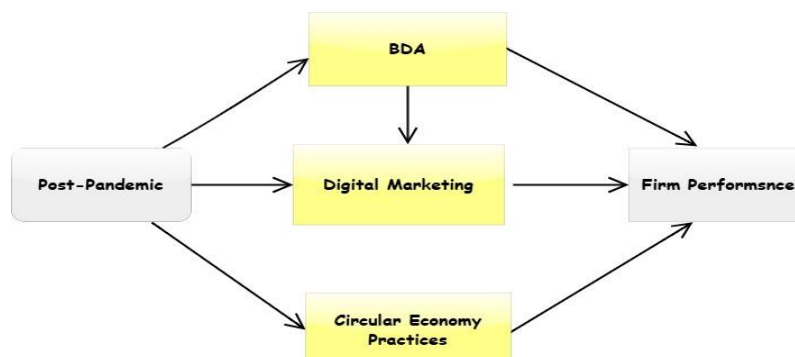

Figure.1 Theoratical Framework

4. Results and Discussion

The findings of the study highlights that the adoption of BDA, Digital marketing and CE in processes has increased in today post-pandemic era. The outcomes also highlights that the adoption of BDA and digital marketing have played a critical role in bolstering business flexibility and driving better performance in postpandemic era.

4.1 BDA Implementation and Its Effect on Firm Performance

The findings elucidated that due to rapid changing demand, businesses have increasing adopted BDA in organizations $(\beta = 0.630), p < 0.05$. BDA emerged as a crucial mechanism to bolster corporate resilience and used advanced analytical techniques (e.g. deep learning and machine learning) to address market uncertainties [23, 24]. The findings also indicated that BDA enhance firm performance $(\beta = 0.573), p < 0.05$) as it enabled companies to predict and track trends in supply and demand, optimize resource allocation and risk management and hence improve efficiency and operational performance [26].

4.2 The Impact of Digital Marketing on Firm Performance

The analysis also found that the usage of digital marketing has increased in post pandemic era $(\beta = 0.721), p < 0.05$) and has positive impact on firm performance $(\beta = 0.637), p < 0.05$. Digital marketing is one of the significant tools that kept the brands in touch with clients on digital platforms during the pandemic. Firms that focused on targeted digital communication had customers who were more engaged and generated better financial performance [27].

Further, the considerable connection between BDA and digital marketing $(\beta = 0.746), p < 0.05$) suggests that BDA based on AI and data-driven insights significantly enhance marketing efforts in the sense of effective pursuit of the right audience and implementation of innovative campaigns [28].

4.3 The Connection between CE Practices and Sustainability

The results revealed that there is a strong positive relationship between CE practices and firm performance$(\beta = 0.533), p < 0.05$. CE initiatives allowed companies to reduce costs, utilize resources more efficiently, and improve sustainability. The application of CE principles at the new circular economy level, when integrated with digital technologies such as blockchain enhances supply chain transparency aids in the efficient management of resources and promotes the adoption of sustainable production practices[21] [18].

4.4 Summary of Key Findings

Table 2 outlines the principal findings of the SEM (structural equation modelling) analysis of employees used to test the hypotheses.

Table 2 Summary of Hypothesis Testing

Hypothesis	Path Coefficient (β)	Significance ($p-value$)	Result
H1	0.630	p<0.05	Supported
H2	0.721	p<0.05	Supported
H3	0.829	Not Significant	Not Supported
H4	0.573	p<0.05	Supported
H5	0.746	p<0.05	Supported
H6	0.637	p<0.05	Supported
H7	0.533	p<0.05	Supported

4.5 Model Fitting Indices

Several fit indices were employed for assessing the model's performance concerning RMSEA, GFI, TLI, NFI, and CFI. All values exceeded the suggested thresholds, indicative of the model's robustness. The specific results are summarized in Table 3.

Table 3 Model Fitting Indices

Metric	Value	Threshold	Result
RMSEA	0.046	<0.08	Acceptable
GFI	0.911	>0.90	Good Fit
NFI	0.913	>0.90	Good Fit
TLI	0.930	>0.90	Good Fit
CFI	0.934	>0.90	Good Fit

4.6 Discussion

The study findings indicates that the in today post-pandemic era digital technologies such as BDA has adopted by companies due to ever changing customer demand and changing consumer behavior. The adoption of BDA has enabled firms to effectively manage digital marketing by providing data trends and patterns which helped in improving firms performance. Moreover, BDA and digital marketing emerged as important drivers in building firm resilience and resilience-driven performance. The findings also elucidated that CE practices helped in reducing waste from production operations which improves firms performance. Additionally, the digital marketing is crucial to keep in touch with customers chamging behaviour as well as to meet emerging consumer needs that also help in improving firm performance. However, there was no big increase in adopting CE practices during the post-pandemic, pointing to the hurdles to the implementation of sustainability efforts. This is perhaps because the firms who were participated in survey have prioritized short-term survival strategies over long-term sustainability strategies.

The overall results demonstrate the highly relevant function of technology in meeting the difficulties presented in the post-pandemic era, with important outcomes for both policy and management.

5. Conclusions and Policy Implication

Using cross-sectional data analyzed through PLS-SEM, the study illustrated the relationships between BDA, CE, and digital marketing alongside business performance. Results indicate that BDA and digital marketing adoption has been increasly adopted by firms in today post-pandemic era, while CE practices has not been extensively adopted in firms. These results imply that, in this post-pandemic world, firms rely on digital tools and analytics to deal with ambiguities and uncertainty leading to better decisions and resilience.

The prominent recommendations for managers are to use BDA for a high level of flexibility in operational activities and better financial efficiency. This research recommends governmental bodies to provide interest-free loans for technological automation to firms. It is also recommended firms to focus more on digital marketing as it provides an opportunity to engage the firms through innovations and target the audience directly, which can strengthen firms performance in the market.

Future Research

Future studies can held similar studies in other geographical regions would help assess whether cultural, regulatory, or economic differences affect the adoption and efficacy of BDA, CE, and digital marketing practices. Future studies can analyze the effect of other technologies on circular economy [40] as well as can analyze the effect of Tor which is widely used tool that provide anonymity and privacy to its users [39] on firm performance. Given the present study's emphasis on Chinese manufacturing firms, discovering other regions could deliver valuable insights into how these policies can be adapted to different contexts and help generalize the findings globally.

Acknowledgements

Not applicable.

Data Availability

The research data related to this work are included in the manuscript. For more information on the data, contact the corresponding authors.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Sheffi, Y. (2020). *The new (ab) normal: Reshaping business and supply chain strategy beyond Covid-19*. MIT CTL Media.

2. Peñarroya-Farell, M., & Miralles, F. (2022). Business model adaptation to the COVID-19 crisis: Strategic response of the Spanish cultural and creative firms. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(1), 39.

3. Yu, Z., Razzaq, A., Rehman, A., Shah, A., Jameel, K., & Mor, R. S. (2021). Disruption in global supply chain and socio-economic shocks: a lesson from COVID-19 for sustainable production and consumption. *Operations Management Research*, 1-16.

4. Ciacci, A., & Penco, L. (2024). Business model innovation: harnessing big data analytics and digital transformation in hostile environments. *Journal of Small Business and Enterprise Development*, *31*(8), 22-46.

5. Bag, S., Dhamija, P., Luthra, S., & Huisingh, D. (2023). How big data analytics can help manufacturing companies strengthen supply chain resilience in the context of the COVID-19 pandemic. *The International Journal of Logistics Management*, *34*(4), 1141-1164.

6. Yu, Z., Khan, S. A. R., & Umar, M. (2022). Circular economy practices and industry 4.0 technologies: A strategic move of automobile industry. *Business Strategy and the Environment*, *31*(3), 796-809.

7. Kaufman, I., Horton, C., & Soltanifar, M. (2023). *Digital Marketing: Integrating Strategy, Sustainability, and Purpose*. Taylor & Francis.

8. Dey, P. K., Malesios, C., De, D., Budhwar, P., Chowdhury, S., & Cheffi, W. (2022). Circular economy to enhance sustainability of small and medium sized enterprises. In *Supply chain sustainability in small and medium sized enterprises* (pp. 10-45). Routledge.

9. Huang, S. L., & Siao, H. R. (2023). Factors affecting the implementation of online food delivery and its impact on restaurant performance during the covid-19 pandemic. *Sustainability*, *15*(16), 12147.

10. Bui, M. T., & Le, H. L. (2023). Digital capability and creative capability to boost firm performance and formulate differentiated CSR-based strategy. *Heliyon*, *9*(3).

11. Chatterjee, S., Chaudhuri, R., Vrontis, D., & Thrassou, A. (2023). Impacts of big data analytics adoption on firm sustainability performance. *Qualitative Research in Financial Markets*, *15*(4), 589-607.

12. Jonsdottir, H. D. (2024). The utilization of BDA in digital marketing strategies of international B2B organizations from a dynamic capability´s perspective: A qualitative case study.

13. Liang, F. Y. (2017). Big Data Analytics: Implications for an International Reinsurer. In *Business Analytics: Progress on Applications in Asia Pacific* (pp. 204-250).

14. Asokan, D. R., Huq, F. A., Smith, C. M., & Stevenson, M. (2022). Socially responsible operations in the Industry 4.0 era: post-COVID-19 technology adoption and perspectives on future research. *International Journal of Operations & Production Management*, *42*(13), 185-217.

15. Sharma, A. K., Sharma, D. M., Purohit, N., Rout, S. K., & Sharma, S. A. (2022). Analytics techniques: descriptive analytics, predictive analytics, and prescriptive analytics. *Decision intelligence analytics and the implementation of strategic business management*, 1-14.

16. Hassan, A., & Mhmood, A. H. (2021). Optimizing network performance, automation, and intelligent decision-making through real-time big data analytics. *International Journal of Responsible Artificial Intelligence*, *11*(8), 12-22.

17. Ijaz, A., Khan, A. A., Arslan, M., Tanzil, A., Javed, A., Khalid, M. A. U., & Khan, S. (2024). Innovative Machine Learning Techniques for Malware Detection. *Journal of Computing & Biomedical Informatics*, *7*(01), 403-424.

18. Shemshaki, M. *Data-Driven Digital Marketing The Art and Science of Intelligent Decision-Making*. Milad Shemshaki.

19. Järvinen, J. (2016). *The use of digital analytics for measuring and optimizing digital marketing performance* (Doctoral dissertation, University of Jyväskylä).

20. Ullah, A., Waqar, M., Nazir, S. S., Adnan, A., Khan, M. A., Raffat, M. W., & Rafi, S. (2024). The impact of information communication technology and financial innovation on the financial performance of Chinese commercial banks. *Remittances Review*, *9*, 364-383.

21. Nandi, S., Sarkis, J., Hervani, A., & Helms, M. (2021). Do blockchain and circular economy practices improve post COVID-19 supply chains? A resource-based and resource dependence perspective. *Industrial Management & Data Systems*, *121*(2), 333-363.

22. Nurminen, M., Mattila, M., & Närvänen, E. (2024). Companies' future visions for circularity: A frame analysis based on Finnish front-runner CE companies. *Cleaner Production Letters*, *7*, 100066.

23. Gupta, S., Chen, H., Hazen, B. T., Kaur, S., & Gonzalez, E. D. S. (2019). Circular economy and big data analytics: A stakeholder perspective. *Technological Forecasting and Social Change*, *144*, 466-474.

24. Awan, U., Shamim, S., Khan, Z., Zia, N. U., Shariq, S. M., & Khan, M. N. (2021). Big data analytics capability and decision-making: The role of data-driven insight on circular economy performance. *Technological Forecasting and Social Change*, *168*, 120766.

25. Humayun, U., Yaseen, M. T., Shahwaiz, A., & Iftikhar, A. (2024). Deep Learning Approaches for Brain Tumor Detection and Segmentation in MRI Imaging. *Journal of Computing & Biomedical Informatics*.

26. Seyedan, M., & Mafakheri, F. (2020). Predictive big data analytics for supply chain demand forecasting: methods, applications, and research opportunities. *Journal of Big Data*, *7*(1), 53.

27. Wang, Z., & Kim, H. G. (2017). Can social media marketing improve customer relationship capabilities and firm performance? Dynamic capability perspective. *Journal of Interactive marketing*, *39*(1), 15-26.

28. Jiwat, R., & Zhang, Z. L. (2022). Adopting big data analytics (BDA) in business-to-business (B2B) organizations–Development of a model of needs. *Journal of Engineering and Technology Management*, *63*, 101676.

29. Yin, S., Zhang, N., Ullah, K., & Gao, S. (2022). Enhancing digital innovation for the sustainable transformation of manufacturing industry: a pressure-state-response system framework to perceptions of digital green innovation and its performance for green and intelligent manufacturing. *Systems*, *10*(3), 72.

30. Gupta, S., Justy, T., Kamboj, S., Kumar, A., & Kristoffersen, E. (2021). Big data and firm marketing performance: Findings from knowledge-based view. *Technological Forecasting and Social Change*, *171*, 120986.

31. Awan, I. A., Sumra, I. A., Mahmood, K., Akram, M., Mujahid, S. K., & Zaman, M. I. (2024). A Reliable Approach For Data Security Framework In Cloud Computing Network. *Migration Letters*, *21*(S11), 923-934.

32. Trabucco, M., & De Giovanni, P. (2021). Achieving resilience and business sustainability during COVID-19: The role of lean supply chain practices and digitalization. *Sustainability*, *13*(22), 12369.

33. Shahriar, S. H. B., Alam, M. S., Arafat, S., Khan, M. M. R., Nur, J. E. H., & Khan, S. I. (2022). Remote work and changes in organizational HR practices during corona pandemic: a study from Bangladesh. *Vision*, 09722629221115234.

34. Bocanet, A., Alpenidze, O., & Badran, O. (2021). Business analysis in post-pandemic era. *Academy of Strategic Management Journal*, *20*(4), 1-9.

35. Zahoor, N., Christofi, M., Nwoba, A. C., Donbesuur, F., & Miri, D. (2024). Operational effectiveness in post-pandemic times: Examining the roles of digital technologies, talent management and employee engagement in manufacturing SMEs. *Production Planning & Control*, *35*(13), 1625-1638.

36. Pantano, E., Pizzi, G., Scarpi, D., & Dennis, C. (2020). Competing during a pandemic? Retailers' ups and downs during the COVID-19 outbreak. *Journal of Business research*, *116*, 209-213.

37. Brewer, P.; Sebby, A. G. (2021). The effect of online restaurant menus on consumers' purchase intentions during the COVID-19 pandemic. International Journal of Hospitality Management, 94, 102777.

38. Fei, S.; Ni, J.; Santini, G. (2020). Local food systems and COVID-19: An insight from China. Resources, Conservation and Recycling, 162, 105022.

39. Ali, H., Iqbal, M., Javed, M. A., Naqvi, S. F. M., Aziz, M. M., & Ahmad, M. (2023, October). Poker Face Defense: Countering Passive Circuit Fingerprinting Adversaries in Tor Hidden Services. In *2023 International Conference on IT and Industrial Technologies (ICIT)* (pp. 1-7). IEEE.

40. Khan, S. A. R. (2022). Circular economy and digital technologies: An evolving trend in environmental research. *Integrated Environmental Assessment and Management*, *18*(4), 853-854.

41. Hamza, M. (2024). Optimizing early detection of diabetes through retinal imaging: A comparative analysis of deep learning and machine learning algorithms. *Journal of Computational Informatics & Business*, *1*(1).