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Application of Concurrent Triangulation for Evaluating and Strengthening the Manufacturing Sector's Impact on Economic Growth and Success

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Abstract
The manufacturing sector has long been acknowledged as a fundamental driver of economic growth and prosperity. However, it confronts significant challenges, including shortages of skilled labour, complex regulatory frameworks, and inadequate investments in technology and infrastructure. This study aimed to address these obstacles by employing a robust concurrent triangulation model that combines questionnaire and in-depth interview to comprehensively evaluate the manufacturing sector. By gathering data from 340 respondents (205 Subjective measurement and 135 in-depth interviews) the transformative potential of key enablers in driving economic expansion and prosperity was examined. The findings of the study indicated that 40.0% of the respondents (136) recognized the adoption of new technologies as a crucial catalyst for sectoral transformation. Furthermore, 30.29% emphasized on the significance of embracing sustainable practices, while 13.82% endorsed the adoption of lean manufacturing techniques as instrumental in achieving economic expansion and prosperity. Additionally, 9.41% and 6.47% of the respondents identified the transformative potential of investment in research and development and the development of a skilled workforce, respectively. In conclusion, the adoption of new technologies emerged as the primary key enabler for transforming the manufacturing sector. Through collaborative efforts, manufacturers and governments can collectively shape a future that is both prosperous and sustainable for all stakeholders involved.

Keywords: *Economic, Expansion, Prosperity, Manufacturing sector, Triangulation, Model.*
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1. Introduction

The manufacturing domain, being an integral constituent of the economic fabric, assumes a pivotal function in stimulating economic proliferation and affluence. Manufacturing, through its workforce engagement and facilitation of economic advancement, serves as a wealth generation mechanism. With a perpetually progressing nature, the manufacturing sphere incessantly confronts novel predicaments. To effectively surmount these challenges, manufacturers must readily adopt and assimilate innovative technologies and methodologies, thus augmenting operational efficacy, curtailing expenses, and amplifying productivity. The primary objective of this study encompasses an evaluative appraisal of the manufacturing sector's contribution towards economic expansion and prosperity, employing the formidable tool of concurrent triangulation. The present study undertakes a comprehensive examination of extant scholarly works pertaining to the subject matter at hand, delineating the various materials and methodologies proffered for the metamorphosis of the manufacturing domain, and elucidating the prospective repercussions thereof.

Manufacturing represents an indispensable constituent within the economic frameworks of numerous nations. It engenders employment opportunities, imparts impetus to gross domestic product (GDP) augmentation, and serves as a catalyst for innovation. Nevertheless, in previous decades, the manufacturing domain encountered formidable obstacles, such as automation, off-shoring endeavours, and escalating rivalry from burgeoning economies. As a consequence, a decrement in manufacturing occupations ensued, accompanied by a shift towards an economy

predominantly centered on services. Nonetheless, in order to counteract this trajectory, policymakers and industry pioneers are presently investigating novel strategies aimed at metamorphosing the manufacturing sector, thereby instigating economic expansion and fostering prosperity. The Manufacturing Association of Nigeria (MAN) has meticulously observed that the tenacity exhibited by manufacturers has not proven sufficiently robust to sustain their engagement in the realm of production subsequent to the unprecedented crisis induced by the pandemic.

Multiple scholarly investigations have underscored the significance of the manufacturing sector in propelling economic expansion. As per a report issued by the National Statistics Bureau, the manufacturing industry demonstrated noteworthy contributions to Nigeria's GDP, accounting for 14% and 19.02% in 2021 and 2022, respectively. Furthermore, with regard to real-time growth, the sector exhibited a tangible GDP growth rate of 2.35% in 2022, compared to 3.35% in 2021, thus indicating a decline in productivity within the nation's manufacturing domains (NBS, 2022).

Manufacturers are compelled to adopt a proactive stance in effecting a transformative shift within the sector. This necessitates substantial investments in novel technologies, infrastructure upgrades, and the cultivation of a highly skilled workforce. Various progressive nations have already undertaken initiatives to overhaul their manufacturing domains, exemplified by Germany's Industry 4.0 and China's Made in China 2025 campaigns. The literature review offers a comprehensive survey of extant scholarly research pertaining to the manufacturing sector, accentuating salient patterns, hurdles, and prospects. It extensively draws upon diverse sources, encompassing academic publications, industry reports, and governmental data, thereby furnishing a holistic portrayal of the present condition of the manufacturing sector.

Manufacturers have faced considerable transformations in the manufacturing sector over the past few years. The emergence of globalization, advancements in technology, and evolving customer preferences have presented manufacturers with fresh obstacles to overcome. To remain competitive, manufacturers must embrace new technologies such as automation, artificial intelligence, and robotics to increase efficiency, reduce costs, and improve productivity. However, the report also notes that the sector faces significant challenges, including a shortage of skilled labour, regulatory burdens, and a lack of investment in technology and infrastructure

However, the manufacturing sector has confronted noteworthy predicaments, encompassing a dearth of proficient labour, escalating expenditures, the imperative to embrace emergent technologies, regulatory encumbrances, and inadequate investments in technology and infrastructure. In order to tackle these challenges, numerous strategies have been put forth, encompassing the assimilation of cutting-edge manufacturing technologies, the cultivation of a proficient workforce, and the encouragement of innovation and entrepreneurship (Jacobsson and Lind, 2014). Nonetheless, the study accentuates the significance of embracing novel technologies and methodologies to enhance operational efficiency, curtail expenses, and amplify productivity.

To explore the role of transforming the manufacturing sector, several literatures of relevant academic and industry publications were reviewed. Data collected from industry, associations and government agencies reports to identify key challenges and opportunities in the manufacturing sector were also analyzed. A methodological avenue for effecting a transformation within the manufacturing sector entails the assimilation of advanced manufacturing technologies, including 3D printing, robotics, and the Internet of Things (IoT) (Gunasekaran et al., 2015; Musa and Musa, 2022). Employing these technologies has the potential to augment productivity, curtail expenses, and elevate product quality within the manufacturing sector. Simultaneously, the cultivation of a proficient workforce constitutes another pivotal facet in the transformative process (Bartel and Lach, 2020). This objective can be accomplished by means of educational initiatives and training programme designed to equip workers with the requisite proficiencies for operating advanced manufacturing technologies. Additionally, the manufacturing sector necessitates the effective allocation of foreign exchange (FX) to enable the importation of essential raw materials, as well as crucial machinery and equipment that may not be domestically obtainable.

Revisiting the revival and rehabilitation of existing refineries is imperative in order to foster local fuel production. Moreover, it is important to give significant attention to the revitalization of major highway corridors, the enhancement of trade facilitation infrastructure, and the continued expansion of the rail system. It is essential that

industrial policies in this country be afforded the opportunity to evolve with appropriate monitoring and evaluation mechanisms, instead of being prematurely abandoned or excessively modified. Ultimately, fostering innovation and entrepreneurship can play a pivotal role in propelling economic expansion and prosperity. By providing incentives for the development of innovative products and services, along with addressing the security concerns related to life and investments in industrial areas, it is possible to establish a solid basis for long-term growth (Gao et al., 2019).

The re-engineering of the manufacturing sector involves a comprehensive overhaul and restructuring of the underlying methodologies and frameworks governing manufacturing processes. This transformative endeavour aims to enhance efficiency, effectiveness, and overall competitiveness (Bohn, 2016). This entails a comprehensive examination and optimization of each facet within the manufacturing process, ranging from the initial stages of product design and production to the subsequent activities of distribution and delivery pertaining to the finished products. Re-engineering the manufacturing sector underscores the significance of incessant improvement and innovation as imperative measures to sustain competitiveness within the global marketplace (Ahn and Song, 2016). A variety of methodologies have been recognized for the objective of restructuring manufacturing processes, including well-known approaches such as lean manufacturing, Six Sigma, Total Quality Management, and Business Process Re-engineering (Gunasekaran et al., 2015). These methodologies primarily concentrate on the identification and eradication of inefficiencies and waste, while concurrently enhancing quality, reducing costs, and increasing productivity. Additionally, they foster innovation, facilitate cost savings, and contribute to job creation. The re-engineering of the manufacturing sector also assumes a critical role in advancing the economic growth of nations. Re-engineering the manufacturing sector is important for competitiveness for several reasons which include the re-engineering of manufacturing processes which can help companies to identify and eliminate inefficiencies, reduce waste, and cut costs. This can help to make products more affordable and increase competitiveness in the marketplace. More so, by the adoption of new technologies and implementing lean manufacturing principles, companies can improve product quality, which will further help to increase customer satisfaction and loyalty. Re-engineering of manufacturing processes can also help to shorten lead times, allowing companies to bring products to market more quickly. This can further assist the companies to respond to changing market conditions and stay ahead of competitors.

Similarly, innovation played a vital role through the re-engineering of manufacturing processes, which is a potential to generate new and inventive products, thus establishing a competitive edge in the market. Companies that are able to offer unique and high-quality products are more likely to succeed in the long term. However, global competitiveness increases the globalized marketplace, companies needed to be competitive not only domestically but also globally. Re-engineering the manufacturing sector can help companies to compete with companies in other climes that may have lower labour costs or other advantages.

A competitive manufacturing sector can also lead to job creation, as companies expand and invest in new technologies and processes. This can have positive economic impacts at the local, regional, and national levels. Re-engineering the manufacturing sector is crucial for companies to remain competitive in the marketplace, respond to changing market conditions, and take advantage of new opportunities for growth and innovation. Re-engineering the manufacturing sector can yield a plethora of advantages, encompassing heightened productivity, diminished costs, elevated quality, shortened lead times, augmented customer satisfaction, and amplified competitiveness. Through the streamlining of processes, eradication of waste, and adoption of new technologies, companies can achieve substantial cost savings, bolster efficiency and output, and enhance their overall financial performance.

The transformation of the manufacturing sector necessitates a concerted endeavour involving policymakers, industry leaders, and the workforce. Policymakers assume a crucial role by offering support through investments in education and training programme, fostering research and development, and formulating policies that incentivize the adoption of advanced manufacturing technologies. Industry leaders play a pivotal part in driving the transformation through investments in cutting-edge technologies, the cultivation of a proficient workforce, and the fostering of innovation and entrepreneurship. The workforce, on

their part, assumes an essential responsibility in this transformation by acquiring the necessary skills to operate advanced manufacturing technologies and adapting to novel manufacturing processes. However, bringing about a transformation in the manufacturing sector requires significant investments in technology and infrastructure, which can be a challenging task for small and medium-sized enterprises (SMEs) that may not have sufficient resources to invest in new technologies. Governments can play a critical role in supporting SMEs by offering incentives, funding, and other resources to aid them in their endeavors to transform their operations.

The manufacturing sector has encountered noteworthy challenges, such as a scarcity of skilled labour, escalating costs, the necessity of adopting new technologies, regulatory burdens, and insufficient investment in technology and infrastructure. Recognizing this gap, the present study aims to leverage the potency of concurrent triangulation to evaluate and augment the manufacturing sector's role in driving economic expansion and fostering prosperity, with the ultimate objective of addressing and resolving the identified challenges.

2. Materials and methods

In this study, the concurrent triangulation model was employed, combining both quantitative and qualitative analyses. The quantitative analysis involved closed-ended questions utilizing Subjective Measurement through questionnaire surveys and descriptive statistics. The qualitative analysis utilized in-depth interviews with thematic analysis. Regression analysis was additionally employed to validate the obtained results. The concurrent triangulation design is illustrated in Fig. 1.

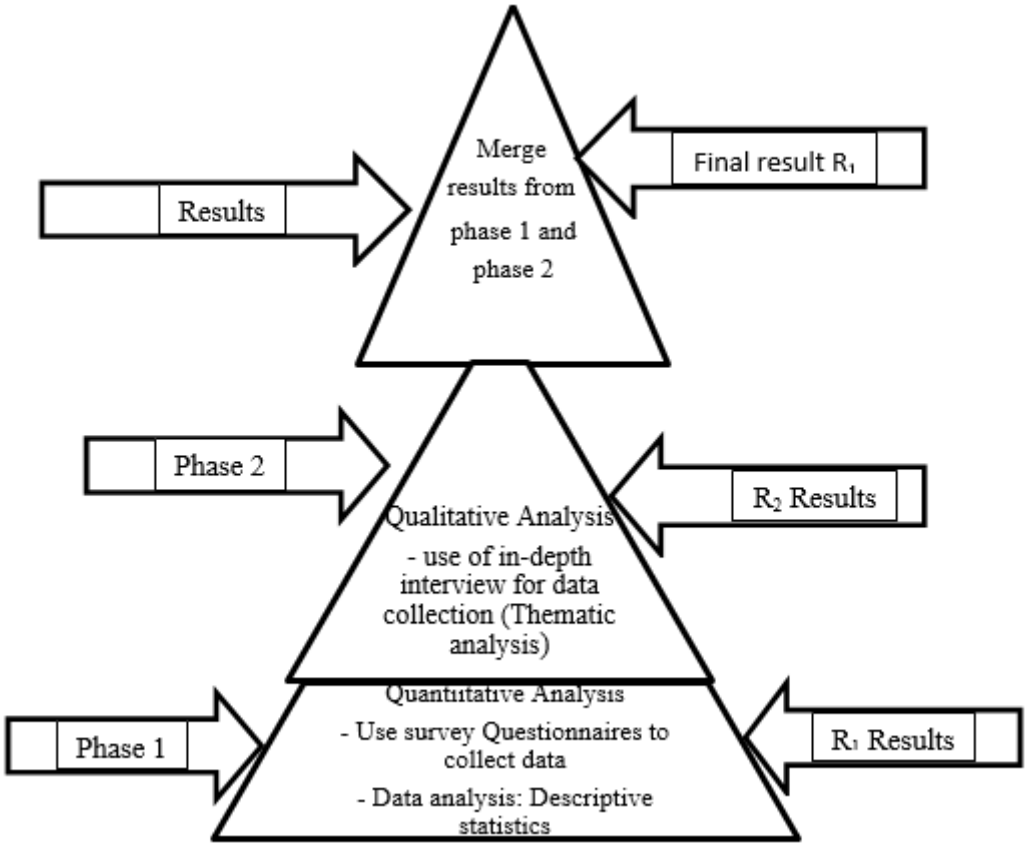

Fig. 1: Concurrent triangulation model (Kingsley-Omoyibo, 2020).

The following hypotheses were tested:

H_{01}: There is no significant relationship between adopting new technologies and transforming the manufacturing sector to drive economic expansion and economic prosperity.

H_{02}: There is no significant relationship between embracing sustainable practices and

transforming the manufacturing sector to drive economic expansion and economic prosperity.

H_{03}: There is no significant relationship between adopting Lean Manufacturing and transforming the manufacturing sector to drive economic expansion and economic prosperity.

H_{04}: There is no significant relationship between investing in research and development and transforming the manufacturing sector to drive economic expansion and economic prosperity

H_{05}: There is no significant relationship between developing the skilled workforce and transforming the manufacturing sector to drive economic expansion and economic prosperity

The e-mail system, utilizing a dedicated account and a professional email address, facilitated the distribution of 250 copies of a close-ended questionnaire related to Subjective Measurement. The recipient list was imported from a CSV file. From this distribution, 82% (or 86 copies of questionnaire\) were deemed usable for analysis. In the subsequent phase, qualitative analysis was conducted through in-depth interviews with a sample size of 150 individuals. Out of these interviews, 70% (or 135 interviews) were identified as usable for analysis. The collected responses were meticulously analyzed and documented. The model was validated using residual statistics. As part of the transformation of the manufacturing sector and the restructuring of manufacturing processes, efforts were made to enhance efficiency, effectiveness, and competitiveness. This encompassed a comprehensive analysis and optimization of all aspects of the manufacturing process, spanning from the design and production of goods to the distribution and delivery of the final products.

3. Results

The quantitative analysis of the responses from the questionnaire is presented in Table 1. A total of two hundred and five (205) respondents were of the view that embracing sustainable practices, investing in research and development, adopting new technologies, practicing lean manufacturing and developing skilled workforce will help to transform the manufacturing sector. Among employees in the manufacturing sector, the highest response rate of 33.66% was observed from those who held the opinion that adopting new technologies will help and assist the transformation of manufacturing sector and drive economic expansion and prosperity. Sixty-four (31.22%) respondents believe in embracing sustainable practices while 13.66% agreed to lean manufacturing with 10.73% opted for investment in research and development and developing skilled workforce.

Table 1: Responses from quantitative analysis (subjective measurement) on manufacturing sector

S/N	Key enablers in the manufacturing sector	Respondents	Percentage (%)
1.	Embracing sustainable practices	64	31.22
2.	Investing in research and development	22	10.73
3.	Adopting new technologies	69	33.66
4.	Lean manufacturing	28	13.66
5.	Developing skilled workforce	22	10.73
	Total	205	100%

Table 2 presents the responses obtained exclusively from the in-depth interviews. From the conducted in-depth interviews, a total of 135 responses were received. Among the respondents, 49.63% favoured the adoption of new technologies, while 28.89% advocated for the implementation of sustainable practices. Additionally, the results indicated that 14.07% of the respondents supported lean manufacturing, and 7.41% emphasized the significance of investing in research and development as means to transform the manufacturing sector and stimulate economic expansion and prosperity.

Table 2: Responses from the qualitative analysis (in-depth interview) on stakeholder in manufacturing sector

S/N	Stakeholder in manufacturing sector	Respondents	Percentage (%)
1.	Embracing sustainable practices	39	28.89
2.	Investing in research and development	10	7.41
3.	Adopting new technologies	67	49.63
4.	Lean manufacturing	19	14.07
5.	Developing a skilled workforce	0	0.00
	Total	135	100%

Table 3 presents the distribution of responses obtained from both the in-depth interviews and the questionnaire section. Among the respondents, 40.00% (136 respondents) expressed the belief that adopting new technologies would play a crucial role in transforming the manufacturing sector and driving economic expansion and prosperity. Interestingly, no responses were recorded for the development of a skilled workforce in the in-depth interviews, but the questionnaire section yielded 22 responses, accounting for 6.47%. Embracing sustainable practices in the manufacturing sector garnered 30.29% (103 respondents), while 13.82% (47 respondents) acknowledged the potential of lean manufacturing to contribute to the transformation of the manufacturing sector and stimulate economic expansion and prosperity. Furthermore, 9.41% (32 respondents) expressed the view that investment in research and development would be instrumental in achieving the transformation of the manufacturing sector and fostering economic expansion and prosperity. The findings indicate that the manufacturing sector represented by 136 respondents, holds a significant consensus (40.00%) regarding the transformative potential of adopting new technologies to drive the manufacturing sector and stimulate economic expansion and prosperity.

Table 3: Quantitative and qualitative analysis (in - depth interview and subjective measurement) on manufacturing sector

S/N	Stakeholders in manufacturing sector	Subjective Measurement	In-depth interview	Total responses	Total Percentage (%)
1	Embracing sustainable practices	64	39	103	30.29%
2	Investing in research and development	22	10	32	9.41%
3	Adopting new technologies	69	67	136	40.00%
4	Lean manufacturing	28	19	47	13.82%
5	Developing a skilled workforce	22	0	22	6.47%
		205	135	340	100%

Table 4 presents the results of the regression analysis conducted. The coefficient of determination, R^2, yielded a value of 0.544, indicating a good level of prediction for the transformation of the manufacturing sector. This implies that the dependent variable, representing the manufacturing sector, accounted for 54.4% of the variability observed in the transformation key enablers and the outcomes of economic expansion and prosperity. The F value of 243.851 indicates that the independent variables included in the regression analysis statistically and significantly predicted the dependent variable, which is the manufacturing sector. Values of R^2 of 54.4% and P>0.000 suggests that the regression analysis is a good fit for the data.

Table 4: Regression analysis for coefficients

Model	R	R^2	Adjusted R squared	S.E.E	F value	df 1	df 2	Sig F change
1	0.738	0.544	0.542	4.195	243.851	1	204	0.000

Dependent variable: Manufacturing sector. R – Correlation of coefficient; R^2 - coefficient of determination; SEE-Standard error of estimate

Hypothesis testing at a significance level of 5% on the data obtained indicated the following: (1) there is a significant relationship between adopting new technologies and transforming the manufacturing sector to drive economic expansion and prosperity, (2) there is a significant relationship between embracing sustainable practices and transforming the manufacturing sector to drive economic expansion and prosperity, (3) there is a significant relationship between lean manufacturing operations and transforming the manufacturing sector to drive economic expansion and prosperity, (4) there is a significant relationship between investing in research and development and the transformation of the manufacturing sector to drive economic expansion and prosperity, and (5) there is a significant relationship between developing the skilled workforce and transforming the manufacturing sector to drive economic expansion and prosperity.

Table 5 shows the output from residual statistics. It demonstrates that the mean value is quite proximate to the true mean of the 100 total responses obtained. At a 95% confidence interval, the margin of error for the mean is 2.270, with an upper bound of 2.270 and a lower bound of 1.761. The standard error of 6.941 and 0.129 show a relatively low value. The predicted model for the development of manufacturing sector was estimated as 64.706+2.015 (stakeholder in manufacturing sector).

Table 5: Standard coefficients for manufacturing sector

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	64.706	6.941		9.322	0.000	51.020	78.391
	Stakeholder in manufacturing sector	2.015	0.129	0.738	15.616	0.000	1.761	2.270

Dependent variable: manufacturing sector

4. Discussion

The results of this study demonstrate that the transformation of the manufacturing sector has a noteworthy influence on expansion and prosperity. This transformation is facilitated by crucial factors including the adoption of new technologies, the embrace of sustainable practices, the implementation of Lean manufacturing principles, investments in research and development, and the development of a skilled workforce. These findings align with previous studies conducted by Bartel and Lach (2020), Gao et al. (2019), Bohn (2016), and Jacobson and Lind (2014). Based on these results, it can be deduced that the successful transformation of the manufacturing sector relies on the effective implementation of these key enablers. Consequently, there is a need to take the following actions:

i. Adopting new technologies: Enhancing competitiveness in the manufacturing sector
can be achieved through the adoption of new technologies, which encompass automation, artificial intelligence, and the Internet of Things (IoT), among other advanced innovations. The integration of these technologies has the potential to optimize manufacturing processes, leading to cost reduction and improved product quality. Supporting this notion, Singh et al. (2013) highlighted the benefits of new technologies in the manufacturing sector. By embracing these advancements, manufacturers can streamline their operations, achieve greater efficiency, and gain a competitive edge in the market.
ii. Investing in research and development: Allocating resources to research and

development endeavours can result in the creation of novel and innovative products, as well as the development of more streamlined manufacturing processes. This, in turn, can establish a competitive advantage within the market.

iii. Focusing on lean manufacturing: Lean manufacturing entails implementing a production system aimed at eliminating waste and maximizing efficiency. By prioritizing lean manufacturing principles, companies can effectively reduce costs, enhance product quality, and shorten lead times.

iv. Collaboration with suppliers: Establishing collaborative relationships with suppliers can make a significant contribution to optimizing the supply chain, improving cost-effectiveness, and elevating product quality. Enhanced communication, joint planning, and the exchange of valuable information between manufacturers and suppliers play key roles in achieving such collaboration, as emphasized by Kumar and Malegeant (2014).

v. Developing a skilled workforce: A proficient workforce is imperative for the manufacturing sector to retain its competitiveness. Investments in training and development programs can ensure that employees possess the necessary skills and knowledge to operate new technologies and implement lean manufacturing principles effectively.

vi. Embracing sustainability: Manufacturing companies can enhance their competitiveness by embracing sustainable practices. This involves reducing waste, improving energy efficiency, and utilizing environmentally friendly materials. Such efforts enable companies to meet the growing demand for sustainable products and reduce their environmental impact.

5. Conclusion

The transformation of the manufacturing sector plays a pivotal role in fostering economic expansion and prosperity. To effectively realize this objective, it necessitates a collaborative effort among policymakers, industry leaders, and the workforce. This collective endeavour entails the adoption of advanced manufacturing technologies, the development of a skilled workforce, and the promotion of innovation and entrepreneurship. By implementing these strategic measures, the manufacturing sector can maintain its indispensable status within the economies of most countries. It will continue to generate employment opportunities and spur innovation, ultimately contributing to sustained economic growth and prosperity. In order to maintain competitiveness in the current globalized economy, manufacturers must wholeheartedly adopt new technologies and processes. To facilitate this transformative endeavour, governments can play a vital role by offering incentives, funding, and additional resources to support small and medium-sized enterprises (SMEs) in their investments towards new technologies and infrastructure. Through collaborative efforts, manufacturers and governments can collectively shape a future that is both prosperous and sustainable for all stakeholders involved. By synergizing their efforts, they can pave the way for enhanced productivity, increased competitiveness, and long-term economic growth.

Conflict of Interest

The authors confirm that this article content has no conflict of interest.

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