

Technological Innovation and its Impact on the Sustainability and Growth of Small Mechanical Services in the Philippines

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Abstract

This study investigated the impact of technological innovation on the sustainability and growth of small mechanical contracting services in the Philippines. It explored the challenges and opportunities these services face in adopting emerging technologies such as digitalization, automation, and sustainable materials. The study examined the extent of technology adoption, the drivers and barriers influencing adoption, and the impact of technology adoption on sustainability, competitiveness, and innovation. A descriptive-correlational research design was employed, using quantitative surveys and semi-structured interviews with owners, managers, and employees of small mechanical contracting firms. The findings indicate a general trend of technology adoption among these services, with widespread use of mobile technology but less adoption of more advanced technologies like 3D printing, VR/AR, and drones. Technological innovation was found to be positively correlated with both sustainability practices and growth. The study concludes that technological innovation and sustainability practices are important factors for the growth of small mechanical contracting services in the Philippines. These services need to adopt advanced technologies and sustainable practices to enhance their competitiveness and achieve sustainable development.

Keywords: Technological Innovation, Sustainability Practices, Growth, Operational Efficiency

Introduction

Micro, Small, and Medium Enterprises (MSMEs), including mechanical contracting services, are crucial to the Philippine economy. However, these services operate in a challenging environment characterized by intense competition and various obstacles within the construction industry. These obstacles include escalating costs, labor shortages, inadequate technology adoption, difficulty competing with larger firms, and environmental concerns, all of which threaten operational efficiency, profitability, and the sector's overall sustainability. The mechanical contracting industry is undergoing significant transformations driven by technological advancements, making it imperative to address these challenges.

Technological innovation offers substantial potential to revolutionize the construction industry, particularly for small mechanical contracting services, by enhancing efficiency, reducing costs, and improving sustainability (McKinsey & Company, 2018). While the importance of technology adoption is globally recognized, smaller businesses often face hurdles such as limited resources, lack of expertise, and regulatory complexities (Christoph Kreiterling, 2023). The Department of Trade and Industry (DTI) emphasizes the role of MSMEs as growth engines, yet their performance is often constrained by limited

financial capacity, poor market information, and a lack of access to innovative techniques and advanced technology. This technology adoption gap in the Philippine context, especially for small mechanical contracting services, necessitates focused research.

This study investigates the challenges and opportunities faced by small mechanical contracting services in adopting emerging technologies like digitalization, automation, and sustainable materials. Specifically, it examines the extent of technology adoption and delves into the key drivers and barriers. These barriers encompass financial constraints (limited resources, insufficient investment), technological barriers (lack of expertise, implementation difficulties), regulatory hurdles (compliance requirements, unclear guidelines), human capital challenges (skills gaps, resistance to change), and market factors (competitive pressures, evolving customer demands).

Furthermore, the study analyzes the impact of technology adoption on sustainability (reduced environmental impact, enhanced resource efficiency), competitiveness (improved cost-effectiveness, productivity, market share), and innovation (new products/services, enhanced quality). Finally, it explores the role of government entities, industry associations, and other stakeholders in supporting and facilitating technology adoption among these firms.

By providing insights into these critical areas, this research aims to contribute to the development of strategies and policies that empower small mechanical contracting services to leverage technological innovation for sustainable growth, thereby strengthening the Philippine economy and enhancing their global competitiveness. The importance of statistics for planning, resource allocation, and capability building is acknowledged, as is the need for stakeholder collaboration to mitigate the negative effects of natural hazards and climate change.

Literature Review

Technological Innovation

The mechanical contracting industry is undergoing a significant transformation driven by technological advancements like digitalization, automation, and sustainable materials, which offer substantial potential to enhance sustainability and competitiveness. However, smaller businesses often face challenges in adopting these innovations due to limited resources, lack of expertise, and regulatory hurdles (Christoph Kreiterling, 2023). Technological innovation drives changes that can optimize internal processes (e.g., productivity, decision-making) and enhance user experience (e.g., communication tools, customer management systems) (<https://www.repsol.com/en/energy-and-the-future/technology-and-innovation/technological-innovation/index>, 2024). Innovation, whether incremental or radical, can provide a competitive edge (Kindred Grey, 2020) and improve customer engagement (<https://sendpulse.com/support/glossary/marketing-innovation>, 2024).

Innovation is crucial for economic growth and requires supportive government policies (Ranga & Kim, 2023). Technological evolution impacts the labor market, increasing efficiency while also prompting shifts in job roles (Daniil Filipenco, 2024). In the context of the Philippine construction industry, which, despite its economic contribution, has been perceived as lagging in technology adoption due to its inherent complexities (Wang et al., 2023), this study emphasizes the importance of technological innovation for the sustainability and growth of small mechanical contracting services. Efficiency gains from automation and AI (Richard-Arkwright, 2023) and the need to adapt to evolving demands (Ng et al., 2020) make technological adoption a necessity for these services to remain competitive, especially considering the sector's conservative tendencies (Sawhney et al., 2020).

Sustainability Practices

The discourse on sustainability practices within the construction industry reveals a strong emphasis on integrating environmentally responsible approaches. Ifiok Enebon and Luna (2023) highlight the importance of sustainable materials and construction methodologies for developing resilient industrial buildings, stressing the need to mitigate environmental impacts and enhance operational efficiency. Concurrently, Lakhi (2024) identifies significant barriers to broader adoption, including limited market demand, lack of political will, and technological gaps, further compounded by economic instability and inadequate infrastructure. These challenges necessitate concerted efforts from policymakers and stakeholders to foster a cultural shift towards sustainability through improved regulatory frameworks, investments in infrastructure, and increased public awareness, as supported by the London School of International Business (2022).

Beyond the inherent environmental considerations, the intersection of sustainability with digital transformation presents a complex dynamic. Juniarti and Omar (2021) raise concerns about the need for clear evidence of digitalization's positive sustainability effects and advocate for ethical considerations in its application, calling for greater academic guidance. Guandalini (2022) echoes this sentiment, emphasizing the relevance of this interplay for practitioners and regulators who must navigate both sustainability imperatives and the ongoing digital revolution. Furthermore, authors like Anupreethi M. (2024) and Humansmart Editorial Team (2024) acknowledge the internal challenges companies face in implementing sustainable practices, from financial constraints to stakeholder engagement, yet underscore the strategic importance of overcoming these hurdles. Kinnunen, Saunila, Ukko, and Rantanen (2022) add that strategic sustainability is tied to competitive positioning. The need to balance environmental responsibility with economic viability remains a central theme, as highlighted by sunbasedata.com (2021), requiring careful project planning and continuous innovation to achieve long-term success.

Enhanced Resource Efficiency

The construction industry is undergoing a digital revolution, with technologies like BIM and robotic layout promising increased efficiency and productivity (Holzman, 2022), though adoption is hindered by human factors and implementation challenges. Concurrently, the demand for sustainable building practices is growing, with technological innovation driving eco-friendly solutions (Evangelista, 2024), while SMEs are leveraging technological development projects to enhance competitiveness (Clovis Freire, 2024). Innovation is recognized as crucial for economic growth (Savchuk, 2019), and technology plays a key role in achieving resource efficiency, leading to cost reduction and improved resilience (Lexicon, 2025; Iheacho, 2025). Emerging technologies are also vital for sustainable development across various sectors (Ragnarson, 2022), and in the Philippine context, technological innovation is essential for the sustainability and growth of small mechanical contracting services, impacting their ability to thrive within the broader economy (Maliashova et al., 2021; Oda et al., 2022; Wei et al., 2024; Mehmood, et al., 2022; Meisels, et al., 2025).

Methodology

This study employed a descriptive-correlational research design to examine the level of technological innovation adoption among small mechanical contracting services in the Philippines and its relationship with sustainability and growth. Data was primarily collected through surveys from owners, managers, and key personnel of these services within the National Capital Region, supplemented by secondary data from

Philippine government agencies and industry reports. A stratified sampling technique was used to select five companies, totaling 53 respondents, ensuring representation across different operational durations and company sizes. The researcher-made questionnaire, validated through pilot testing with industry professionals, consisted of sections assessing technological innovation, sustainability practices, and growth, utilizing a four-point Likert scale. Reliability testing yielded excellent results (0.908 to 0.933). Data collection involved obtaining formal permission from participating firms and distributing the questionnaire via online channels. Statistical analysis included weighted mean to describe the variables, Pearson's r correlation to determine relationships between variables, and regression analysis to assess the predictive power of technological innovation and sustainability practices on growth.

Part 1. Level of Adoption of Technological Innovation

POINT	SCALE	VERBAL INTERPRETATION
4	3.47 - 4.00	Very High Level of Adoption
3	3.32 – 3.46	High Level of Adoption
2	3.17 – 3.31	Low Level of Adoption
1	3.00 – 3.16	Very Low Level of Adoption

Part 2. Sustainability Practices of Small Mechanical Contracting Services

POINT	SCALE	VERBAL INTERPRETATION
4	3.36 – 3.55	Highly Implemented
3	3.36 – 3.35	Implemented
2	3.26 – 3.35	Partially Implemented
1	1.00 – 3.25	Not Implemented

Part 3. Key Indicators of Growth

POINT	SCALE	VERBAL INTERPRETATION
4	3.34 – 3.37	Significant Growth
3	3.30 – 3.33	Moderate Growth
2	3.26 – 3.29	Minimum Growth
1	3.21 – 3.25	No Growth

Results

Part 1. Level of adoption of Technological Innovation

Table 1 indicates a generally positive trend of technology adoption among small mechanical contracting services in the Philippines, with an overall weighted mean of 3.34 signifying a 'High Level of Adoption'. Notably, the belief that technological innovation is crucial for maintaining a competitive edge ranked highest (mean of 3.62), highlighting a strong awareness of technology's strategic importance. Conversely, adoption of advanced technologies like 3D printing/prefabrication, VR/AR, and drones/remote sensing was lower (means ranging from 3.02 to 3.17), suggesting that while these services recognize the value of technology, the adoption of more cutting-edge innovations faces challenges, potentially due to investment costs, skill requirements, or perceived immediate relevance.

Table 1. Level of Adoption of Technological Innovation Statistical Result

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. The organization has a dedicated budget for investing in new technologies.	3.45	High Level of Adoption	3.5
2. The organization regularly attends industry events and conferences to stay updated on the latest technological advancements.	3.43	High Level of Adoption	5
3. The organization has a formal process for evaluating and adopting new technologies.	3.45	High Level of Adoption	3.5
4. The organization utilizes cloud-based software and platforms for project management and collaboration.	3.28	Low Level of Adoption	7
5. The organization uses mobile devices and applications to improve field operations and communication.	3.47	Very High Level of Adoption	2
6. The organization has implemented 3D printing or prefabrication technologies to enhance efficiency and reduce waste.	3.02	Vey Low Level of Adoption	9.5
7. The organization utilizes virtual reality (VR) or augmented reality (AR) technologies for design visualization and training.	3.02	Vey Low Level of Adoption	9.5
8. The organization has adopted drones or other remote sensing technologies for site inspections and surveys.	3.17	Low Level of Adoption	8
9. The organization actively seeks partnerships and collaborations with technology providers and research institutions.	3.42	High Level of Adoption	6
10. The organization believes that technological innovation is crucial for maintaining a competitive edge in the market.	3.62	Very High Level of Adoption	1
Overall Weighted Mean	3.34	High Level of Adoption	

Part 2. Sustainability Practices of Small Mechanical Contracting Services

Table 2 indicates that small mechanical contracting services generally "agree" with their implementation of sustainability practices (overall weighted mean of 3.38), highlighting a recognition of sustainability's importance for long-term success (highest-ranked indicator, 3.55). However, lower scores for indicators like "Conducts regular environmental assessments" (3.25) suggest areas needing improvement. This implies that while sustainability is valued strategically, consistent implementation across all areas varies, necessitating prioritization, stakeholder engagement, and internal capacity building.

Table 2. Sustainability Practices of Small Mechanical Contracting Services Statistical Result

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. <i>The organization has a written sustainability policy that guides its operations.</i>	3.36	Implemented	6
2. <i>The organization has a designated team or individual responsible for overseeing sustainability initiatives.</i>	3.31	Partially Implemented	8
3. <i>The organization conducts regular assessments of its environmental impact.</i>	3.25	Not Implemented	10
4. <i>The organization actively seeks to reduce its carbon footprint through energy efficiency and renewable energy sources.</i>	3.32	Partially Implemented	7
5. <i>The organization prioritizes the use of sustainable building materials and construction practices.</i>	3.38	Implemented	4.5
6. <i>The organization has implemented water conservation measures in all projects and operations.</i>	3.38	Implemented	4.5
7. <i>The organization promotes waste reduction and recycling initiatives throughout its operations.</i>	3.42	Implemented	3
8. <i>The organization considers the lifecycle cost of materials and equipment in its decision-making processes.</i>	3.47	Highly Implemented	2
9. <i>The organization engages in community outreach and education programs related to sustainability.</i>	3.29	Partially Implemented	9
10. <i>The organization believes that sustainability is essential for the long-term success of its business.</i>	3.55	Highly Implemented	1
Overall Weighted Mean	3.38	Implemented	

Part 3. Key Indicators of Growth of Small Mechanical Contracting Services

Table 3 specifies the growth performance over the past three years, small mechanical contracting services in the Philippines showed an overall weighted mean of 3.27, indicating "Minimum Growth" and a generally positive perception, though with room for improvement. The strongest indicator was "consistently achieved high levels of customer satisfaction" (3.37, "Significant Growth"), suggesting customer satisfaction as a key strength. Conversely, the lowest-ranked indicators, "Increased investment in R&D" and "Expanded service offerings and diversification" (both 3.21, "No Growth"), reveal lagging progress in these areas, highlighting the need for greater focus on R&D and diversification for sustained

growth.

Table 3 Key Indicators of Growth of Small Mechanical Contracting Services Statistical Result

Indicators	Weighted Mean	Verbal Interpretation	Rank
1. The organization has consistently increased its annual revenue over the past 3 years.	3.28	Minimum Growth	6.5
2. The organization successfully expanded its market share in the mechanical contracting sector in the past 3 years.	3.26	Minimum Growth	8
3. The number of projects that the organization have completed annually has significantly increased over the past 3 years.	3.25	No Growth	9.5
4. The organization has achieved a significant improvement in profitability over the past 3 years due to optimized project costs and efficiency.	3.32	Moderate Growth	3.5
5. The organization have consistently achieved high levels of customer satisfaction, leading to repeat business and positive referrals over the past 3 years.	3.37	Significant Growth	1
6. The organization have significantly increased its investment in research and development (R&D) over the past 3 years to innovate and improve its services	3.21	No Growth	10.5
7. The organization have successfully implemented new technologies that have measurably improved our efficiency and productivity over the past 3 years.	3.32	Moderate Growth	3.5
8. The organization's brand recognition and reputation in the market have significantly improved over the past 3 years.	3.30	Moderate Growth	5
9. The organization have successfully expanded its service offerings and diversified into new market segments over the past 3 years.	3.21	No Growth	10.5
10. The organization have achieved significant reductions in operational costs while maintaining or improving quality over the past 3 years.	3.25	No Growth	9.5

Overall Weighted Mean	3.27	Minimum Growth	
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Part 4. Relationship Between the Level of Adoption of Technological Innovations and Sustainability Practices of Small Mechanical Contracting Services

The study found a strong, statistically significant positive correlation ($r = .894$, $p < .01$) between the level of technological innovation adoption and sustainability practices in small mechanical contracting services. This indicates that higher adoption of technological innovations is significantly associated with greater implementation of sustainability practices, suggesting that technology plays a crucial role in driving sustainability within this sector

Table 4. Relationship Between the Level of Adoption of Technological Innovations and Sustainability Practices of Small Mechanical Contracting Services Statistical Result

Variables	Statistical Treatment (Pearson's)	p-value	Decision	Interpretation
Adoption of technological innovations and sustainability practices	$r = .894$ (Strong correlation)	.000**	H_0 rejected	Significant
**Significant @.01				

Part 5. Relationship Between the Level of Adoption of Technological Innovations and Growth of Small Mechanical Contracting Services

This research examined the relationship between technological innovation adoption and the growth of small mechanical contracting services. A strong positive correlation was found (Pearson's $r = .815$, $p < .001$), indicating a statistically significant relationship where higher adoption of technological innovations is associated with greater growth. This finding suggests that embracing technological innovation is crucial for driving growth in this sector.

Table 5. Relationship Between the Level of Adoption of Technological Innovations and Growth of Small Mechanical Contracting Services Statistical Result

Variables	Statistical Treatment (Pearson's)	p-value	Decision	Interpretation
Adoption of technological innovations and growth	$r = .815$ (Strong correlation)	.000**	H_0 rejected	Significant
**Significant @.01				

Part 6. Relationship Between the Sustainability Practices and Growth of Small Mechanical Contracting Services

The analysis revealed a strong positive correlation (Pearson's $r = .806$, $p < .01$) between sustainability practices and the growth of small mechanical contracting services, indicating that greater implementation of sustainability is significantly associated with higher growth. This statistically significant finding ($p < .01$) supports the conclusion that sustainability practices are a key driver of growth in this sector.

Table 6. Relationship Between the Sustainability Practices and Growth of Small Mechanical Contracting Services Statistical Result

Variables	Statistical Treatment (Pearson's)	p-value	Decision	Interpretation
Sustainability practices and growth	$r = .806$ (Strong correlation)	.000**	H_0 rejected	Significant
**Significant @.01				

Part 7. Regression Analysis of Level of Adoption of Technological Innovations and Sustainability Practices on Growth of Small Mechanical Contracting Services

Regression analysis demonstrates that both the adoption of technological innovations and sustainability practices are significant predictors of the growth of small mechanical contracting services. Technological innovations account for 66.4% of the variability in growth ($F = 100.924$), with a beta coefficient (β) of .815, indicating that each unit increase in technological innovation adoption leads to a .815 unit increase in growth ($p < .01$). Similarly, sustainability practices explain 64.9% of the variability in growth ($F = 94.309$), with a beta coefficient (β) of .806, showing that each unit increase in sustainability practices adoption results in a .806 unit increase in growth ($p < .01$). Both predictors have a p-value of .000, confirming their statistical significance and leading to the rejection of the null hypothesis.

Table 7. Regression Analysis of Level of Adoption of Technological Innovations and Sustainability Practices on Growth of Small Mechanical Contracting Services Statistical Result

Predictors	Dependent Variable	β	R^2	ANOVA	t	p-value	Decision	Interpretation
Adoption of technological innovations	Growth	.815	.664	$F = 100.924$	10.046	.000**	Null Hypothesis Rejected	Significant
Sustainability practices		.806	.649	$F = 94.309$	9.711	.000**	Null Hypothesis Rejected	Significant

**Significant @ .01								

This study of small mechanical contractors in the Philippines reveals a general adoption of technological innovations, particularly mobile technology, alongside a positive commitment to sustainability. While advanced technology adoption is limited, there's a strong positive correlation between technology adoption, sustainability practices, and business growth. Specifically, higher technology adoption is significantly associated with increased sustainability and growth, with technology adoption being a slightly stronger predictor of growth than sustainability practices alone. The research recommends a strategic action plan that includes developing formal sustainability policies, expanding carbon footprint reduction, actively pursuing community engagement, strategically investing in technologies to enhance efficiency and customer satisfaction, and fostering a synergistic approach to leverage technology for sustainability, ultimately maximizing business growth and competitiveness.

Discussion

The study reveals that small mechanical contractors in the Philippines, while recognizing the importance of technological innovations, particularly mobile applications, and sustainability practices, exhibit uneven implementation. There's a positive sentiment towards sustainability, shown through lifecycle costing and waste reduction, indicating an awareness of its long-term strategic value. However, the sector shows lower adoption rates for advanced technologies and gaps in formal sustainability policies, carbon footprint reduction, and community outreach. This suggests that while there's progress, a more comprehensive and proactive approach is needed to fully leverage the potential of both technology and sustainability."

"Strong positive correlations between technology adoption, sustainability practices, and business growth highlight a critical interdependency. Notably, higher technology adoption is linked to increased sustainability and greater growth, with technology being a slightly stronger predictor of growth than sustainability. This indicates that strategic technology investments can catalyze both operational improvements and a stronger commitment to sustainable practices, driving business success. The recommended action plan, focusing on formalizing sustainability policies, expanding community engagement, strategically investing in relevant technologies, and fostering a synergistic relationship between technology and sustainability, provides a clear roadmap for the sector to capitalize on these interconnected drivers of growth and competitive advantage.

Conclusion/Recommendation

This study concludes that small mechanical contracting services in the Philippines demonstrate a foundational adoption of technological innovations, particularly mobile technology, and acknowledge the strategic value of sustainability. However, the adoption of advanced technologies like 3D printing, VR/AR, and drones remains limited, and formal sustainability practices, including comprehensive carbon footprint reduction and community engagement, require further development. Customer satisfaction and operational efficiency are key growth drivers, with technological innovation and sustainability practices strongly correlated with and predictive of growth, technology showing a slightly stronger influence. These findings underscore the interconnectedness of technology, sustainability, and growth in this sector.

To foster growth, it is recommended that small mechanical contracting services, with support from stakeholders, prioritize a multi-pronged approach. This includes: incentivizing the adoption of advanced technologies through training and financial support; facilitating the development of formal sustainability policies with community engagement and environmental assessments; promoting strategic investment in innovation and service diversification with a focus on sustainability; actively integrating technology to enhance sustainability practices; championing sustainability as a growth driver; and fostering integrated approaches to technology and sustainability. A coordinated effort to implement these recommendations will enable these services to capitalize on the synergistic benefits of technology and sustainability for sustained growth and competitiveness in the Philippine market.

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