Adoption of Advanced Manufacturing Technology by SMEs in Kenya: Effect on Performance and Policy Implications

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Abstract

This study examined the adoption of advanced manufacturing technology (AMT) by small and medium-sized enterprises (SMEs) in Kenya and its effect on their performance. The study utilized a mixed-methods approach, combining qualitative and quantitative data collected through Interviews and structured questionnaire respectively.The target population constituted SME owners and Managers across various manufacturing sectors in Kenya. The study employed a stepwise regression model to analyze the results. Findings indicate a positive correlation between AMT adoption and operational performance, including increased production efficiency, product quality, and market competitiveness. The study also shows a significantly positive relationship between use of AMT by SMEs in Kenya and their ability to develop and sustain competitive advantage in their operations by employing both planning and design technologies. Specifically, the study found a significant and positive relationship between design technologies and performance of SMEs in Kenya ($p<0.001$), and between planning technologies and performance of SMEs in Kenya ($p<0.001$). Further, the study found that manufacturing technologies do not have a signigificant positive effect on performance of SMEs in Kenya when considered together with planning technologies and design technologies ($p=0.698$).The paper recommends that SMEs should adopt design technologies and planning technologies that are aligned to their manufacturing process. The study also recommends that appropriate policies that encourage adoption of AMT should be developed to enhance performance of SMEs given their pivotal role in national economic development.

Key words: Advanced Manufacturing Technology, Small and Medium Entreprises, Performance.

Introduction

The rapid evolution of global manufacturing practices coupled with the integration of planning technologies, design technologies, and manufacturing technologies of AMT in the production process, has become crucial for enhancing productivity and competitiveness. Rahman and Benett (2009) attribute the remakable industrial achievements as observed in Asian Countries to the adoption of AMT in their production processes. The ability of the Asian countries to develop their own technological capabilities that suit their operating environment, has also contributed to sustaining their growth and competitive advantage globally, from their early stages of industrialization.

Darbanhosseiniamirkhiz and Wan Ismai (2012), reckon that AMT provides a global solution required by manufacturing companies to remain competitive and manage their operating costs as they meet their customer needs. Although AMT has evolved from being managed by human beings using planning technologies, to computer networks using design technologies, to the latest era of smart and connected networks of manufacturing things, at times employing Internet of Things (IoT), it is still considered to be a system of interconnected or stand alone computers that simplify complicated operations in manufacturing (Yang et al., 2019).

Small and medium size entrepises (SMEs) are important players in the economic development of many Countries (Forth & Bryson, 2019) reducing unemployment levels through job creation acrosss all sectors of the economy, consequently increasing output growth (Criscuolo et al., 2014). In Kenya, the size of companies is defined by the number of employees, annual turnover or total capital investments (Musebe et al., 2020). The SMEs in Kenya are those considered to have 1-99 employees with Micro enterprises constituting less than 10 employees, small enterprises having 10-49 employees and medium sized enterprises having 50-99 employees (Musebe et al., 2020).

At least 24% of GDP in Kenya is accounted for by SMEs, with small enterprises alone contributing 12% of GDP. Medium enterprises contibute 11% of GDP, and both of them-Small and Medium entreprises-contribute over 90% of total labor force (GOK Sessional Paper No. 05, 2020). Kenya, anticipated the manufacturing sector to contribute 10% of the annual growth rate by the year 2030 and be the source of innovation, competitiveness, provision of goods and services and entrepreneurial skills (GOK, 2012). There are over 7.4 million SMEs employing approximately 14.9 million Kenyans in various sectors of the economy (KIPPRA, 2024). The contribution to GDP of SMEs in Kenya at 24% is lower than that of South Africa (55%), Hungary (54%) and Malaysia (37%), suggesting opportunities for improvements with appropriate process and policy interventions (KIPPRA, 2024).

Progress on achieving Sustainable Development Goals (SDG) has been observed to be lagging even as the set date of completion of this important global initiative is fast approaching (UN, 2024). Many countries including Kenya, continue to face a range of unique and interconnected development challenges that include a cost-of-living crisis, with economic, social and environmental challenges compounding increased poverty and hunger, consequently diminishing the importance and urgency of meeting SDG goals. If appropriate process and policy interventions are enacted, SMEs and AMT can be used to help countries, including Kenya, meet the SDGs.

Evidence has emerged to show that large manufacturing companies, while employing correct AMT in their manufacturing processes achieve competitive advantage in their industry, by reducing their operation costs and improving the product quality to meet customer needs (Musebe et al., 2020). This study aims to use this evidence and contribute to knowledge by examining the association between adoption of AMT and performance among SMEs in Kenya.

Literature Review

Researchers have continued to conceptualize AMT differently over the years, from flexible and programmable technologies designed for process efficiency and flexibility of production (Meredith, 1988), to being components of the computer integrated manufacturing paradigm (Sun, 2000). This study considers AMT to broadly include planning technologies, design technologies and manufacturing technologies used in the manufacturing process to reduce costs, improve product quality and enhance performance in manufacturing companies.

Planning Technologies

Planning technologies that are majorly adopted for AMT, tend to follow the plan based strategy development approach and are useful especially to SMEs, as they complement large companies in contributing to the economy (Buczacki & Laporte, 2016). This study considers planning technologies associated with AMT to include; Materials requirement planning (MRP), Manufacturing resource planning (MRPII), Computer preventive maintenance planning (CPM), Just in time (JIT), Management information systems (MIS), Enterprise resource planning (ERP), Total quality management (TQM) and, Customer relationship management (CRM).

In determining factors that affect adoption of AMT, Darbanhosseiniamirkhiz and Wan Ismai (2012) suggest three factors that could be considered in the case of SMEs; environmental, organizational and technological contexts. The organizational context which refers to the style of management employed by SMEs, offers a great challenge for SMEs when adopting planning technologies. A company is more likely to benefit when adopting AMT and especially planning technologies when it opts for AMT that fits its structure and employee skills (Ghani et al., 2000).

In Kenya, according to Douglas et al (2017), SMEs have dynamic organizational structures with 70% of them failing within the first three years of incorporation. Further, since acceptance of technology takes several years to achieve after implementation, many SMEs in Kenya fail even before realizing the benefits of AMT if they adopt them in their early years of incorporation (Hajipour et al., 2011). From the foregoing, a hypothesis to test the effect of planning technologies on performance of SMEs was developed.

H_1: *There is a significant relationship between adoption of planning technologies and performance of SMEs in Kenya.*

Design Technologies

According to Idrissia et al. (2012), adopting design technologies is easier when SMEs integrate their internal strengths with the external environment factors. This study recognizes design technologies to include: Computer aided design (CAD), Computer aided Engineering (CAE), Computer aided process planning (CAPP) and Group technology (GT). When adopting design technologies, SMEs have to address both customer and competitive pressure to sustain their competitive advantage in their industries. Design technologies allow SMEs to develop new products by designing tools and machinery used in their production (Nyori et al., 2015). This allows SMEs to be agile and meet the prevailing external conditions caused by changing customer needs and the market. In addition, design technologies allow SMEs to reduce their payroll costs arising from the high productivity and efficiencies, reduce customer complaints by incorporating enhanced product features which increase customer retention and loyalty leading to lower product pricing through reduced waste and re-work during the manufacturing process, with an overall improvement of quality and performance of the product.

Adoption of design technologies according to Kumar et al. (2017) has a positive relationship with education and employee training, organizational structure, management know-how, technical know-how, and manufacturing strategy. Diaz Reza et al. (2019) reckons that when SMEs implement design technologies appropriately, it eases the implementation of planning technologies in the production system. In order to realise full benefits such as excellent innovation and new product development, SMEs are advised to include activities that lead to improving employee skills. This study investigated the following hypothesis with regard to design technologies:

H*$_2$*: Adopting design technologies has a direct and positive effect on the performance of SMEs in Kenya

Manufacturing Technologies

The study used ten indicators to determine the adoption and effect of manufacturing technologies dimension of AMT in SMEs in Kenya. The indicators included: Computer aided manufacturing (CAM), Computer integrated manufacturing (CIM), Computer numerically controlled machines (CNC), Numerically controlled machines (NC), Flexible manufacturing systems (FMS), Computer aided inspection (CAI), Industrial robots (IR), Automated guided vehicles (AGV), Automated storage and retrieval systems (AS/RS) and Program logic controllers (PLC). It is critical to distinguish between SMEs employing manufacturing technologies in their production process and owning the technology. According to Das and Nair (2010), SMEs using manufacturing technology without owning it may be a deliberate strategic plan to transfer manufacturing and its associated technologies to a third party, to reduce their operation costs. Manufacturing technologies tend to be capital intensive at the initial stage of implementation and require a detailed research and adequate planning before carrying out the investment. It is therefore evident that SMEs may choose to either own and employ manufacturing technologies in their production processes or employ manufacturing technologies in their production process without owning them. They may however realize improved performance arising from actual use rather than ownership (Devaraj & Kohil, 2003).

Although not a pre-requisite for adoption, SMEs use manufacturing technologies to realize what planning and design technologies have envisaged.They develop competitive advantage by exploiting both the tangible and intangible resources they own as long as the resources are Valuable, Rare, Inimitable, and Sustainable (Diaz-Reza et al, 2019). This study investigated the following hypothesis with regard to manufacturing technologies:

H*$_3$*: Adoption of manufacturing technologies have a significant and positive effect on performance of SMEs in Kenya

Methodology

This study was a descriptive cross-sectional study that comprised manufacturing companies in Kenya that were members of Kenya Association of manufacturers (KAM) as at 31st of November 2023. Planning technologies, design technologies and manufacturing technologies were used to operationalize AMT, while performance was operationalized using non-financial metrics-` customer satisfaction, employee retention and market share (Ahmad & Zabri, 2016). A self adminstered questionnaire was used to collect data from the respondents. The study employed a stratified sampling method across the industrial sector in Kenya with 80 questionnaires sent to SMEs. A total of 63 returned questionaires were found to be appropraite for analysis giving a response rate of 78.75%. This is considered adequate for studies on AMT. Diagnostic tests were done to confirm if the data were normally distributed to allow for parametric tests to be undertaken, while descriptive statistics and stepwise multiple linear regression analysis was used to develop the best regression model for testing the relationship between the study variables.

Results

Industry Analysis

All sectors in the manufacturing industry according to KAM classification were represented in the study. The top three sectors that responded to the study questionnaire were SMEs in the electrical sector (22.22%), textile and apparel sector (17.46%), and food and beverages sector (15.87%) while timber, plastic and rubber had the least response rate (1.59%). With regard to the size of the company, the study found that 14.29% of the entreprises were micro, 28.57% were small and a majority (57.14%) were medium size entreprises, indicating that most of the SMEs in Kenya are medium size and could be encouraged to grow and become large manufacturing companies by enacting policies that encourage growth in the manufacturing industry. Majorly, this study presents views from medium size entreprises as shown in Table 1.

Table 1: Size of Entreprise

Number of Permanent Employees in Entreprise	Frequency	%
Less than 10 (Micro-entreprises)	9	14.29
Between 10 and 49 (small Entreprises)	18	28.57
Between 50 and 99 (Medium Entrepises)	36	57.14
Total	63	100

The study sought to determine the operational period of the SMEs since their incorporation. Results indicated that 9.52% of the SMEs had been in operation for less than 3 years and 90.48% more than 3 years. Consequently, the result validate the reliability of data used in the study as most of it emanated from SMES that had overcome the initial set-up challenges that consume 70% of SMEs in Kenya within the first 3 years of incorporation (Douglas, et al., 2017).

Adoption of Advanced Manufacturing Technology by SMEs

Results show that 73.02% of SMEs had adopted a form of AMT within the first 3 years of incorporation in their production process while only 26.98% had not as illustrated in Table 2. The results suggest that adoption and effective use of a form of AMT by SMEs within 3 years of their incorporation, enable them to deliver products and services that meet customer expectations in terms of quality and price, contributing to their good performance, and enables them to overcome initial challenges attributed to failure of SMEs in Kenya within three years of incorporation.

Table 2: Adoption of Advanced Manufacturing Technology by SMEs

Did the SME adopt any form of AMT in the production process within 3 years after incorporation?	Frequency	%
Yes	46	73.02
No	17	26.98
Total	63	100

The study indicates that 47.62% of the SMEs had been using AMT in their production process for more than 10 years while 36.51% had employed AMT for between 0-5 years in their production process. Atleast 15.87% had employed AMT for between 5-10 years. This implies that with adoption of AMT, SMEs become better positioned to compete effectively and grow their market share by developing and sustaining competitive advantage in the industry.

The results also show the dominant manufacturing process among SMEs to be the continous process (25.40%), Batch processing (20.63%), High volume production (14.29%), and flexible manufacturing (11.11%). A total of 7.94% of the SMEs did not indicate the dominant manufacturing process they used in their production process. The continuous process allows SMEs to reduce set up times and generation of waste production encountered in production lines before they stabilize enhancing production. Results are presented in Table 3.

Table 3: Dominant Manufacturing Process

Manufacturing Process	**Frequency**	**%**
Continuous flow process	16	25.40
Flexible manufacturing	7	11.11
Assembly Line	6	9.52
Job shop	6	9.52
High volume production	9	14.29
Manufacturing cells	1	1.58
Batch processing	13	20.63
Missing	5	7.94
Total	63	100.0

A total of 39.68% of the SMEs were found to manufacture between 25% and 75% of their production volume on order with 28.57% of the SMEs producing over 75 of their production volume on order. Some of the SMEs (4.76%) did not indicate the proportion of the manufacturing they did on order. Results are presented in Table 4. This demonstrates that adoption of AMT leads to improved operational performance, customer retention, increased production efficiency, product quality, and market competitiveness that translate into SMEs having a reliable market for their products. Manufacturing on order allows SMEs to manage their costs by reducing inventories and possible product obsolescence. This is also an indication of a stable and sustained market for the SMEs.

Table 4: Production Volume by Order

Percentage of Production by Order	Frequency	%
Less than 10%	9	14.29
Between 10% and 25%	8	12.70
Between 25% and 75%	25	39.68
More than 75%	18	28.57
Missing	3	4.76
Total	63	100.0

Diagnostic Tests

Diagnostic tests that included reliability test, normality test and multi-collinearity test were done on the data before conducting parametric tests.

Reliability Test

Using Cronbach (α), the results confirm that collected data provided reliable deductions on the study variables as advocated by Deng et al. (2017). Table 4 show that Cronbach (α) had a minimum value of 0.842 for market share and a maximum value of 0.963 for planning technologies which were within the acceptable range for the study (Cronbach (α) between 0.58 and 0.97). The least reliability results for Market share could be due to its reliance on external analysis with costs that have no direct impact to performance of SMEs.

Table 4: Reliability Test of Study Variables

Variable	Number of Cases	Number of items in Scale	Cronbach's Alpha (α)	Mean
Planning Technologies	63	23	0.963	86.17
Design Technologies	63	21	0.944	78.56
Manufacturing Technologies	63	23	0.901	80.53
Customer satisfaction	63	14	0.921	60.39
Employee Retention	63	18	0.950	71.66
Market Share	63	15	0.842	58.41

Acceptable values of Cronbach's (α) for the study are between 0.58 and 0.97

Normality Test

Skewness, Kurtosis and Shakiro - Wilk tests were used to determine normality of the study variables. Acceptable values of skewness and Kurtosis for the study was between -1.96 and +1.96. while the acceptable value for Shapiro - Wilk test was p >0.05. The observed skewness of the data was between -0.833 and 0.128 while Kurtosis of the data was between -0.623 and 1.089. Similarly Shakiro - Wilks test had the following results; a minimum value of 0.934 and a maximum value of 0.986. These results show that the collected data for the study was normally distributed and parametric tests could be used for its analysis as in Table 5.

Table 5: Normal Distribution Test for the Study Variables

VARIABLES	Number of Cases	Skewness	Kurtosis	Shapiro-Wilks
Planning Technologies	62	-0.833	1.089	0.956
Design Technologies	62	-0.436	0.570	0.964
Manufacturing Technologies	62	0.128	0.953	0.986
Customer Satisfaction	62	-0.523	-0.623	0.934
Employee Retention	62	-0.330	-0.559	0.955
Market Share	61	-0.702	0.949	0.952

Multi-Collinearity Test

Multicollinearity relates to a situation where the predictors in a study are to a high extent correlated. The test for multicollinearity was undertaken within the framework of tolerance and Variance Inflation Factor. The acceptable values for the study were for tolerance to be greate than 0.2 and variance inflation factor of 5. The results show that there was no multicollinearity between the variables. The results are presented in Table 6.

Table 6: Multicollinearity Test

Variable	Collinearity Statistics	
	Tolerance	VIF
Planning Technology	0.410	1.938
Design Technology	0.345	1.938
Manufacturing Technology	0.314	3.186

a. Dependent Variable: Performance of SMEs in Kenya

Hypothesis Testing

This was done through correlations between performance of SMEs in Kenya, planning technologies, design technologies and manufacturing technologies. A forward stepwise regression analysis was performed to identify the optimal model to predict performance of SMEs in Kenya. The predictors were; Planning technologies, Design technologies and Manufacturing technologies with Performance of SMEs in Kenya as the dependent variable. Arising from the correlations in Table 7, the following variables were expected to enter in the model in the following order; first expected variable to enter, Design technologiess (0.618), second variable Planning technologies (0.595) and finally Manufacturing technologies (0.594) depending on the significance of the partial correlations on the model.

Table 7: Correlations of Variables

Correlations					
		Performance of SMEs in Kenya	Planning Technologiies	Design Technologies	Manufacturing Technologies
Pearson Correlation	Performance of SMEs in Kenya	1.000	0.595	0.618	0.594
	Plannining Tecnologies	0.595	1.000	0.740	0.787
	Design Technologies	0.618	0.740	1.000	0.709
	Manufacturing Technologies	0.594	0.787	0.709	1.000

The study adopted a criterion at a probability of F to enter ≤ 0.05 and a probability of F to remove ≥0.100 to make the model stable. Results in Table 8 show the optimal model of the study included only 2 variables, design technologies and planning technologies. The study found that Manufacturing technologies was not significant in predicting performance of SMEs in Kenya in the presence of design technologies and planning technologies, and therefore was not entered. Further, this result suggests that SMEs in Kenya observe enhanced performance through adoption of design technologies and planning technologies. Indeed both design and planning technologies can be customised to each SME enabling them to develop competitive advantage, while manufacturing technologies are generic and standard in each sector and provide a common base/framework from which the SMEs can operate to produce a standard product in their respective sectors.

Table 8: Variables Entered/Removed

Variables Entered/Removed[a]			
Model	Variables Entered	Variables Removed	Method
1	Design technologies		Stepwise (Criteria: Probability-of-F-to-enter <= 0.050 Probability-of-F-to-enter >=0.100
2	Planning Technologies		Stepwise (Criteria: Probability-of-F-to-enter <= 0.050 Probability-of-F-to-enter >=0.100

a: Dependent Variable: Performance of SMEs

In the model summary presented in Table 9, the first model shows that Design technologies cause 37.1% of variations in performance of SMEs in Kenya (R^2=0.381, Adjusted R^2=0.371). The final model that included both design technologies and planning technologies demonstrated a strong fit, accounting for a substantial proportion of variations in performance of SMEs in Kenya. The results show that design technologies and planning technologies have a moderately strong and positive correlation with performance (R=0.650) and together account for 40.3% (an increase from 37.1% caused by design technologies alone) of variations in performance of SMEs in Kenya (R^2 = 0.423, Adjusted R^2 = 0.403). These results are fundamental and show that SMEs in Kenya would greatly benefit by having improved performance, if they adopt and correctly implement design technologies and/or/with planning technologies in their manufacturing process.

Table 9: Model Summary

					Change Statistics				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	R square Change	F Change	df 1	df2	Sig. F Change
1	.618[a]	.381	.371	.41811	.381	36.990	1	60	<.001
2	.650[b]	.423	.403	.40730	.041	4.227	1	59	.044

a. **Predictors: (Constant), Design Technologies**
b. **Predictors: (Constant), Design technologies, Planning Technologies**

Results of ANOVA show that both the first model (F=36.990, p<0.001) and the second model (F=21.603, p<0.001) were fit to determine the relationship between Design technologies, planning technologies and performance of SMEs in Kenya. Results are presented in Table 10. Further these results show a significant relationship between design technologies, planning technologies and performance of SMEs in Kenya. Douglas et. al (2017) identified having a good product or service and maintaining good relationship with custmers to be key success factors for SMEs in Kenya, while high taxes and too much regulation formed some of the impediments to their success. The synergy between design technologies and planning technologies ensures that SMEs offer products that meet the the customer needs, allowing them to grow their markets in the process. The results also justify the need for the government of Kenya to develop and implement policies aimed at reducing the costs for design technologies and planning technologies to help SMEs crystallize their performance and reduce the high failure rates encountered by SMEs after incorporation.

Table 10: ANOVA

Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	6.466	1	6.466	36.990	<.001[b]
	Residual	10.489	60	0.175		
	Total	16.955	61			
2	Regression	7.168	2	3.584	21.603	<.001[c]
	Residual	9.788	59	0.166		
	Total	16.955	61			

a. **Dependent variable: Performance**
b. **Predictors: (Constant), Design technologies**
c. **Predictors: (Constant), Design Technologies, Planning Technologies**

In the first model, the coefficient of design technologies was 0.415 indicating that 1 unit change of design technology is associated with 0.618 unit change in performance of SMEs ($t = 6.082$, $p<0.01$, $\beta = 0.618$). In the second model, both Design technologies ($t = 2.677$, $p = 0.01$, $\beta = 0.394$) and planning technologies ($t = 2.056$, $p = 0.044$, $\beta = 0.302$) had positive standardized coefficients, suggesting their contribution to performance of SMEs in Kenya indicating that, together, a unit change in design technologies will lead to 0.394 unit changes, while a unit change in planning technologies will lead to 0.302 unit change in performance of SMEs in Kenya.These findings underscore the importance of both design AMT and planning AMT in determining the performance of SMEs in Kenya. Results are presented in Table 11.

Table 11: Coefficients

Coefficients[a]								
Model		Unstandardized B	Coefficient Std Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics	
1							Tolerance	VIF
	Constant	2.521	.261		9.647	<.001		
	Design Technologies	0.415	.068	.618	6.082	<.001	1.000	1.000
2	Constant	2.346	.268		8.744	<.001		
	Design Technologies	.265	.099	.394	2.677	.010	.452	2.211
	Planning Technologies	.198	.096	.302	2.056	.044	.452	2.211

a. **Dependent variable: Performance**

The excluded variables in model 1 of the stepwise regression included manufactuing technology ($p=0.434$) and planning tecehnology ($p=0.044$) showing that from the three variables, only design technologies ($p<0.001$) was significant as a predictor of performance of SMEs. In the second model, manufacturing technologies ($p=0.698$) was not significant in predicting performance of SMEs in Kenya. Results are shown in Table 12.

Table 12: Excluded Variables

Model		**Beta In**	**t**	**Sig.**	**Partial Correlation**	**Collinearity Statistics**		
						Tolerance	VIF	Minimum Tolerance
1	Manufacturing Technology	.114[b]	.788	.434	.102	.498	2.010	.498
	Planning Technology	.302[b]	2.056	.044	.259	.452	2.211	.452
2	Manufacturing Technology	-.066[c]	-.390	.698	-.051	.345	2.897	.314

a. Dependent Variable: performance of SMEs in Kenya
b. Predictors in the Model: (Constant), Design Technologies
c. Predictors in the Model: (Constant), Design Technologies, Planning Technologies

Discussion of Results

Advanced manufacturing technology has been found to have a positive relationship on performance of organizations. Nyori and Ogola (2015) found that superior plants that used more than 3 types of AMTs reported better performance compared to small plants that were employing less than three types of AMTs in their production process. Agreably, Musebe et al (2020) found that large manufacturing companies that choose and employ the correct type of AMT in their production process observe better results. When manufacturing companies choose the correct type of AMT, they develop a fit between their capabilities and the external environment enhancing efficiency in meeting customer needs. Further, Costa and Lima (2008) found that AMT had a positive contribution on performance and manufacturing goals that include, low cost of production, enhanced product quality, product delivery time, manufacturing flexibility and innovativatiness when considered alongside manufacturing system decision areas that include capacity and performance.

The findings in this study on the application of AMT are similar to the study by Haruna et al. (2015) in a study of SMEs, which found that AMT had a significant and positive relationship with the performance of SMEs as they enabled them to achieve better performance. The results showed that design technologies have a more significant effect on performance of SMEs followed by planning technologies when considered together with manufacturing technologies. Design technologies enable SMEs to be innovative in providing their products and services to their customers and in the process gain competitive advantage in their industries.

The results of this study also agree with Chege et al. (2019) who found that design technologies allow SMEs to optimize and streamline their workflow, increase productivity by anticipating the manufacturing process to be employed, improve the quality of the product by developing both two-dimensional (2D) and 3-dimensional (3D) drawings that depict the final product and level of detail in the design, and improve documentation communications. Planning technologies on the other hand, allow SMEs to appreciate the inventory levels they hold (taking cognisance of the present), identifying which additional ones are needed (determining future needs) and then scheduling their production or purchase (meeting customer needs).

Further, the results show that manufacturing technologies do not have a significant effect on performance of SMEs as they tend to be generic in most industries. As observed by Das and Nair (2010) SMEs can opt to employ manufacturing technologies in their production process and improve their performance without neccesarily owning them. This provides SMEs with an option of designing and planning their production process and use manufacturing technologies owned by a third party. Ultimately, SMEs may still benefit from using manufacturing technologies like CNC, IR, AGV by contracting them from other companies, consequently avoiding their high acquisition costs.

Conclusions and Policy Implications

Design technologies have the most effect on performance of SMEs in Kenya in the presence of both planning technologies and manufacturing technologies. They, like CAD and CAPP, can be adopted through the use of stand alone computers without having to integrate them in the complete manufacturing process, to reduce the costs associated with their acquisition and integration in the complete manufacturing process. Design technologies are the link between customer needs through the marketing department and new product development through manufacturing technologies. Therefore, SMEs benefit when they employ design technologies by reducing the time required to transform customer needs to a proto type and into the final product by incorporating all the required product features and performance attribute, as required by the customer into the final product.

Planning technologies increase the variations of changes observed on performance by 4.2% in the presence of both design technologies and manufacturing technologies. This finding is important for SMEs in meeting customer orders. Planning technologies like, MRP, MRPII, CPM, JIT, MIS, and TQM are important in efficient management of the production process as they optimize the level of inventories held at any instance by SMEs. Optimal inventories reduce obsolescence, pilferage and avail required capital for the business. Further, planning technologies allow SMEs to incorporate customer needs into the product, enhancing customer satisfaction and increasing market share.

Although the effect of manufacturing technologies on performance is not significant in the presence of design technologies and planning technologies, SMEs having robust manufacturing technology like the flexible manufacturing systems and computer aided inspection, are agile towards responding to the changing customer and market needs. They can employ synergies between design technologies, planning technologies and manufaacturing technologies (employing CAD, and CPM, CAM to develope products, maintain production equipment and manufacture the product) to reduce their operation costs, enhance product quality and improve their performance.

More so, SMEs can manage costs associated with AMT by initially using stand alone computers/systems with integration of these stand alone computers into a complete manufacturing system as the second phase of implementing AMT in the manufacturing process. From the foregoing, SMEs need to develop policies that enhance the synergy of AMT systems they intend to adopt to increase their benefits from the use of AMT that include low operation costs, increased customer satisfaction, increased market share, employee retention and enhanceed performance.

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