Enhancing Technological Capabilities In The Manufacturing Industry In Developing Countries Through The Exploitation Of Production Strategies

Mukasa Norbert

Abstract: This study undertook to discern the effect the production strategy dimension had on technological growth in a developing country. It utilized robust indicators that measured the penetration of advanced manufacturing technologies in the Ugandan machine tool driven industry. Poor or the lack thereof of comprehensive production strategies had a profound effect on the development of this industry. It modeled the relationships between these indicators and production strategies. The strongest strategic motivation that drove Ugandan firms to invest in advanced manufacturing technologies was its competitive advantage followed by reduction in labor costs. In addition some strategies presented formidable barriers to the adoption and penetration of advanced manufacturing technologies. The study brings to the fore results that contrast with what has been espoused in the developed world. It provides interesting insights into strategies that influence the growth of the manufacturing industry in a typical developing country.

Index Terms: AMT, Developing countries, Manufacturing strategy, Modeling, Production strategy, Technology growth.

1 INTRODUCTION

Production strategies barely fulfill their function in the manufacturing sector in developing countries. Rather than exploit new technologies to break into world class competition, they are used as tools to enhance the image of the firm. This trend limits the scope and capabilities of advanced technologies to those that focus on the customer at best or reduce production costs at worst. The benefits of technology use are far ranging—from increasing productivity, to improving flexibility, to producing higher quality products, to reducing production costs [1], [2], [3] as cited in [4]. These all constitute strategic motivations relevant to a firm in its pursuit of technology enhancement. Three broad categories of production strategies are analyzed in this paper: Process improvement, cost reduction and customer focused strategies. There is a relationship between the level of sophistication of a firm and the category of production strategies it embraces. Firms that make process improvement strategies their central motivation have factored in their ability to compete at the world stage. The use of cost reduction strategies on the other hand, demonstrate the inability of the firm to fully envisage the advantages associated with technological growth. A firm that has this strategy as its central motivation will normally acquire new technologies with a view to replacing workers rather than empowering them. Customer focus being the central tenet of quality management, firms that use this approach are found to have often achieved a high level of mastery of their production process [5]. According to [5], in their previous on-site observations, they noticed that the level and type of educational background and the extent of functional experience were poor proxies for the level of technical skills: for example, some extremely skilled machinists operating on computerized numerically controlled machines had only two or three years of experience and no post-secondary diploma. They also noticed that, in the more sophisticated firms, an extensive use of computer-based technologies by the non-production employees was almost invariably associated with a higher Advanced Manufacturing Technology (AMT) adoption rate. Mechling *et. al.* [6], measure a firm's breadth of adoption of AMT's as the number of different types of advanced manufacturing technologies used by each firm. They used a survey instrument identifying 17 possible such technologies. Thus, a firm's breadth of adoption can range from "0" (a firm which has no AMT) to "17" (a firm which has adopted all 17) In their study [5], find that strategic motivations focusing on process improvement and customers are the strongest determinants of AMT adoption levels. They represent strategic motivations for further AMT adoption corresponding to operational measures proposed by [7], to assess manufacturing success in terms of the quality of products, flexibility of the manufacturing process and delivery. Other measures related to cost reduction motivations are derived mainly from the work of [8]. The results showed that cost reductions (labor costs and cost of finished products), although quite important, did not appear to be of primary concern. In the end as noted in [4], the decision on whether or not to acquire advanced technologies depends on the benefits that the technology provides and the costs associated with its adoption. This paper presents findings of a study carried out in a typical developing country. It analyses the correlates between production-related strategic decisions and technological growth.

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2 METHODS

2.1 Research Design

The study was by a cross-sectional survey and the instrument used for collecting data was a questionnaire. The structure of the questionnaire is single tiered and required only quantitative responses. Both numeric and categorical (ordinal) data types are used depending on the variable being measured.

2.2 Research Approach

The approach used in this study was quantitative in nature. The completely randomized sampling technique is used. The sampling frame used is the 2003 Uganda Bureau of Statistics business register. Within the population, data is only collected from those firms that had machine tools. The resulting sample size is 39 firms out of a population of 1960 manufacturing firms in the business register that employed five or more people Given the small size of the data set compounded with the fact that three of the four dependent variables are count outcomes, nonparametric techniques are mainly employed in the analysis. However, quantile or linear regression is used for the continuous variable (ratio).

2.3 Statistical Analysis

The main statistical tool used for data analysis is Intercooled Stata 8.2. Epidata software is used for data entry and Microsoft Excel for computerized random sampling. A confidence interval of 95% is used so P values less than 0.025 are considered statistically significant. In order to determine whether the data met the regression assumptions, the following regression diagnostics are used. The Cronbach's alpha coefficient, data validity tests, detection of unusual and influential data, normality of residuals tests and data transformations, checking the construct reliability of the data variables, co-linearity of predictor variables checks and predictor independence tests. In addition, the following post regression tests are performed. Alkaike information criteria (AIC), link tests to detect model specification errors and Multivariate fractional polynomial models.

2.4 Operationalization of Model Variables

2.4.1 Dependent Variables

In order to test the robustness of the hypotheses, the methodology set out to analyze four different measures of technological activity.

1. Ims - Measures the total number of integrative and managerial systems in use.
2. Sds - This is a count variable reflecting the total number of systems, devices and stations in a firm.
3. AMT - measures the total number of advanced technologies in use (ims + sds).
4. Ratio - measures the ratio of sds to ims this is a measure of integration.

These resulting four dependent variables captured the main measures of technological activity and the construct reliability for these perceptual variables proved to be quite satisfactory, with a Cronbach's alpha coefficient of 0.814.

2.4.2 Independent Variables

The survey instrument measures the technical capabilities of the different categories of employees, as the actual percentage of employees within each category who use computer based technologies on a daily basis. Production strategies are measured on five-point Likert scale and are addressed in the survey instrument as follows: "*On a scale of 1-5 indicate how the following strategic motivations would influence or influenced your decision to adopt AMT's.*

2.5 Hypothesis

Based on the above the following hypothesis is formulated:

H_o: The interaction between production strategy and technological skills of employees of Ugandan firms are not determinants for the degree of automation. The following Multivariate regression model is used to test this hypothesis

$$Dep_{ijk} = \beta_0 + \beta_1 (PS)_{ij} + \beta_2 (TS)_{ik} + \beta_3 (PS)_{ij} \times (TS)_{ik} + \varepsilon_i \quad (1)$$

Where

Dep_{ijk}= the dependent variable (*ims, sds, AMT or ratio*)

$(PS)_{ij}$= effect of firm *i* with dimension *j* of production strategy

$(TS)_{ik}$= effect of firm *i* with technical capability *k* and

$(PS)_{ij} \times (TS)_{ik}$ = Interaction effects between strategic motivations and technical skills

3 Results and Discussions

Whereas process improvement strategies ranked highest amongst Ugandan firms' strategic priorities ($\bar{x}$ > 75% see figure 1), regression analysis revealed they are not significant predictors to AMT adoption. Rather customer-focused (competitive advantage and domestic market share), and cost reduction (labor costs), strategies played a more significant role in adoption trends.

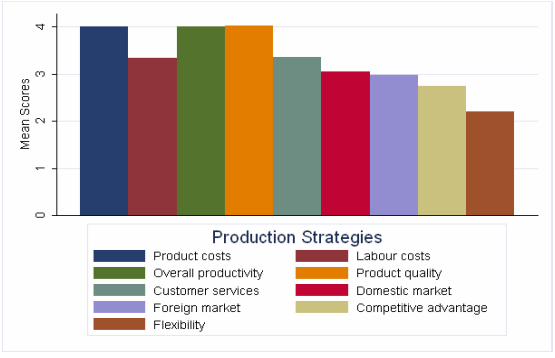

Fig. 1. Mean score for production strategies on a five – point likert scale

Table 1 displays the results of regressing employee skills on one hand and production strategies on the other as main effects against the dependent variables. The relatively low impact production strategies have on technological growth is evident. Out of a total of nine predictor variables of production strategies, only three are found to have significant effects on various measures of technological growth. The strongest strategic motivation that drives Ugandan firms to invest in AMT's is the superior image of the firm followed by reduction in labor costs. Apparently firms look keen on having a competitive advantage over their rivals in industry. No strategic motivation is seen to drive companies to integrate their systems devices and stations, however customer-focused 'increased domestic market share", impeded integration efforts. Worth noting is the negative correlation between both

blue collar skills and integration efforts on one hand and secretarial skills and integration efforts on the other (see table 1). This could be interpreted as - both these categories of employees view the integration of system devices and stations as a threat to their employment.

TABLE 1
SIGNIFICANT REGRESSION ESTIMATES OF MAIN EFFECTS ON DEPENDENT VARIABLES

Dependent variables:	IMS	SDS	AMT	RATIO
Employee skills				
Clerical employees		-1.26***		1.20***
Secretaries		1.56*	0.92*	-1.35****
Functional managers	1.07**	2.76***	1.41***	
Engineers	0.93***		0.99***	
Blue collar workers		1.26****	0.50**	-1.75****
Psuedo R^2	32.0%****	45.0%****	43.4%****	21.1%
Goodness of fit	17.0%	55.2%	0.0%	
Production strategies				
Labor Cost reduction		0.53**		
Domestic Market				-3.12**
Competitive advantage	0.57**	1.78***	0.77**	
Psuedo R^2	6.6%	22.9%****	5.86%	33.4%****
Goodness of fit		0.0%		

Reduction in labor costs, which is a cost reduction strategy, strongly moderates the effects of technical skills of all categories of employees effectively changing their relationships. This strategy deters the acquisition of IMS's among the secretaries who may perceive it as a means to replace them (see Table 2). This result conforms to the findings by Lefebvre *et. al., [5].* Strategies perceived to reduce labor costs moderate the effects of secretaries and functional managers towards SDS adoption, the former changing form to a deterrent of SDS adoption. Unmistakably, labor cost reduction strategy is the biggest moderating factor for employee skills amongst the strategic motivations.

TABLE 2
MODERATING ROLE OF LABOR COST REDUCTION

Dependent variables:	IMS	SDS	AMT	RATIO
Employee skills				
Clerical employees	2.30*	-5.17**		8.37****
Secretaries	-6.18***	-23.80**	-5.87***	-6.14****
Functional managers	6.56**	25.67***	7.93***	
Engineers				1.77****
Blue collar workers				-3.83****
Production strategies				
Labor Cost reduction		-4.04**		0.53****
Interaction factors (Employee skills * Reduction in labor costs)				
Clerical employees	-0.62*			-1.95****
Secretaries	1.87****	9.57**	1.88****	
Functional managers	-1.67**	-6.64**	-1.90**	1.35****
Engineers				-0.59****
Blue collar workers				0.66****
Psuedo R^2	36.4****	51.4%****	47.3%****	52.8****
Goodness of fit	25.3%	79.7%	2.1%	

The cost reduction strategy that sought to reduce labor costs also plays a pivotal role in moderating the effect of technical skills on the way firms were integrating their systems, devices and stations. This strategy moderates the relation with the engineers' skills effectively changing the relationship (see table 1 & 2). Blue collar workers who were opposed to any integration efforts that were perceived to have an effect on their job security are moderated by this strategy to further strengthen their resolve. Increased domestic market share strongly moderate the way technical skills of functional managers and to some extent engineers determine technological trends (see Table 3). Uncharacteristic results are observed when functional managers interact with the domestic market share strategy (see table 1 & 3). Functional managers exhibit conspicuous resistance towards measures of technological growth once it is considered in light of increasing the domestic market share. Engineering skills are moderated by this strategy in a way that eliminates all together any correlation with AMT adoption.

TABLE 3
Moderating role of increased domestic market share

Dependent variables:	IMS	SDS	AMT	RATIO
Employee skills				
Clerical employees		-2.82**		
Secretaries				
Functional managers	-4.34***		-4.03**	-4.62**
Engineers				
Blue collar workers				
Production strategies				
Domestic Market		-39.3**	-13.17*	-11.07**
Interaction factors (Employee skills * Domestic Market share)				
Clerical employees				
Secretaries				
Functional managers	9.40****		9.39***	8.00**
Engineers			2.28**	1.97**
Blue collar workers				
Psuedo R^2	39.1%****	50.1%****	50.4%****	48.1%
Goodness of fit	53.7%	69.5%	14.8%	

Superior image of the firm, while a strong predictor to most measures of technological growth (see table 1), did not pose a challenge in terms of moderating the effect of skills (see table 4). This strategy negatively moderates the effect of clerical skills towards expansion of soft technologies. Once again this trend can be attributed to the perception that the introduction of customer friendly software for example, is one step closer to eliminating the need for these clerical employees.

4 CONCLUSION

It is evident that Ugandan firms are in their infancy with regard to AMT adoption. That is why there is a clear trend of primarily cost reduction strategies moderating the way the predictor variables affect adoption. This is in agreement with *[5],* who proposed an evolutionary pattern of moving from primarily cost related considerations in the earlier phases of automation to the inclusion of other considerations of a less financial nature in the later stages. This study notes the resistance of blue collar workers and secretaries towards integration of system devices and stations. It further notes the resistance of clerical employees towards any effort in improving hardware technologies. Apparent from the results, process improvement strategies, though of greatest importance in manufacturing, do not play any role in the Ugandan manufacturing sector. This result contradicts the findings of [5], who ranked the importance of process improvement and customer focused strategies as first and second respectively.

TABLE 4
MODERATING ROLE OF COMPETITIVE ADVANTAGE

Dependent variables:	IMS	AMT	RATIO
Employee skills			
Clerical employees	-1.71**	-1.62**	
Secretaries			
Functional managers	2.64**	3.06***	
Engineers		1.40*	
Blue collar workers			-1.86*
Production strategies			
Competitive advantage	-1.20*	-1.29*	
Interaction factors (Employee skill * Competitive advantage)			
Clerical employees	1.92**	1.49*	
Secretaries			-3.60*
Functional managers			
Engineers			
Blue collar workers			
Psuedo R^2	37.5%****	49.5%****	60.9%****
Goodness of fit	35.9%	8.8%	

It maybe a different case for Ugandan firms where the technical and strategic benefits of AMTs have probably never been understood and are thus limited to firm image. It is therefore not surprising that competitive advantage, though a primary strategy for Ugandan firms, plays an insignificant role in pushing the same firms into integration of SDS's - a move that would be perceived as attempting to maximize the utilization of their hardware devices in production related activities for the benefit of customers. There is a need for industry to remodel the emphasis currently placed on process improvement strategies since at the moment they do not shape technological trends as compared to cost reduction and customer focused strategies. By doing this developing countries like Ugandan will have taken the much needed stride towards nurturing their manufacturing industry to penetrate world class markets.

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