

Role of Intangible Assets in the Adoption of Advanced Manufacturing Technologies (AMT's) in Developing Countries: Case Study of Uganda

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ABSTRACT

This study analyses the machine tool driven industry in a developing country. It models the relationships between measures of Advanced Manufacturing Technology (AMT) penetration, adoption trends and three sets of predictor variables that are intangible. The study was carried out in 39 firms found to be using machine tools. The results show that education levels of blue collar workers, engineers and managers were instrumental to the investment in systems, devices and stations (SDS), while clerical employees are instrumental in integrating these technologies. The Chief Executive Officer (CEO) and environmental issues were strong influences. The strongest single strategic motivation that drove Ugandan firms to invest in AMT's was the superior image of the firm followed by reduction in labour costs. Finally the study provides interesting insights into the relatively atypical parameters that characterize this industry in a developing country.

KEYWORDS: Advanced Manufacturing Technologies (AMT), Modelling, Developing countries, Intangible assets.

1.0 INTRODUCTION

The manufacturing industry in developing countries is generally characterised by low growth, low volume/capacity, lacks high responsiveness and consequently cannot survive in highly competitive markets. Small-medium batch sizes and non-flow line production technologies are typical of industries in this sector. It is a common practice in industry to expect the investment in AMT to pay back in a relatively short period of 4-5 years. Therefore in the decision problem, the expression related to time is not taken into account. However, AMT's must be viewed in a financial and strategic way as some of the benefits are intangible, such as, gaining full control of the business and other subjective factors like flexibility, learning, capacity increment and competitive advantage. These thus render traditional appraisal methods inappropriate.

In developing countries small manufacturing firms are the norm rather than the exception employing the majority of manufacturing employees and can contribute enormously to the vitality of these economies. It is normally assumed small firms do not have the resources to make extensive use of AMT's however the level of innovation of smaller firms is apparently non-existent among larger manufacturers. The general trend world wide to achieve efficiency and utilization levels of mass production, while retaining the flexibility that job shops have in batch production through Flexible Manufacturing Systems (FMS), cannot be overlooked.

This paper investigates the role intangible assets have on the adoption of AMT's in Uganda. Influences of functional groups, the Chief Executive Officer (CEO) and customers as well as the technical skills of white and blue collar workers are the underlying dimensions analyzed. In addition production strategies related to process improvement, cost reduction and customer foci are examined for any relationship to AMT adoption.

2.0 METHODOLOGICAL ISSUES

2.1 Study design

The sampling frame used was the 2003 Uganda Bureau of Statistics business register. Data was collected from a total of 39 firms out of 1960 manufacturing firms on the business register that employed 5 or more people. In order to ensure that all manufacturing activities are represented stratified random sampling methods were used based on the firms' activities. Within the sample data was only collected from those firms that had machine tools. Given the small size of the data set compounded with fact that 5 of the 7 dependent variables were count outcomes, nonparametric techniques were employed in the analysis. Logistic regression is however used to analyze the dichotomous variable USER.

2.2 Operationalization of model variables

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

- User -This is a dichotomous variable taking a value of 1, if the plant uses any of the 25 technologies and 0, otherwise.
- Ims -Measures the total number of integrative and managerial systems in use.
- sds -This is also a count variable reflecting the total number of systems, devices and stations that a firm has.
- AMT -measures the total number of advanced technologies in use (ims + sds).
- expctd -measures the total number of advanced technologies, (ims + sds), that a firm expects to implement within the next three years..
- breadth -this value takes on the mathematical form $AMT + expctd$.
- ratio -measures the ratio of ims to sds.

These resulting seven 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 0.82.

2.2.1 Hypotheses

Based on the above three hypotheses were tested.

H1: Technical skills of all groups of employees have no positive effect on the level of automation in the Ugandan machine tool driven industry.

H2: Influences of internal and external proponents are not determinants of the level of automation in the Ugandan machine tool driven industry.

H3: There is no positive relationship between production strategies and the degree of automation within Ugandan machine tool driven firms.

3.0 RESULTS AND DISCUSSION

3.1 Contribution of employee skills to AMT adoption

Table 1 shows the summary of results of regression of employee skills on AMT adoption

From the results in table 1, employee skills had no significant effect on firms' plans to invest in advanced manufacturing technologies or on whether firms' use advanced manufacturing technologies or not but had a significant effect on the degree to which a firm uses integrative and managerial systems.

Table 1: Summary of employee skills regressed against dependant variables

Dependant variable	Pseudo-R ²	P-value gof	Significant variables	P-values	Coeff.	Null hypothesis	Model
user	0.3520	-	-	-	-	Accepted	Insignificant
Ims	0.3204	0.1696	MGR ENG	0.014 0.003	1.07 0.933	Rejected	Okay
Model for ims:							
$\ln(ims_i) = -0.126 \times CE_i + 1.56 \times SEC_i^2 + 2.76 \times MGR_i + 1.23 \times \sqrt{ENG_i} + 1.29 \times \sqrt{BCW_i} - 3.67$							
Sds	0.4497	0.5517	CE MGR BCW	0.032 0.019 0.002	-1.26 2.76 1.29	Rejected	Good
Model for sds:							
$\ln(sds_i) = -0.133 \times CE_i + 0.716 \times SEC_i^2 + 1.07 \times MGR_i + 0.934 \times \sqrt{ENG_i} + 0.129 \times \sqrt{BCW_i} - 0.758$							
AMT	0.4339	0.0084	MGR ENG BCW	0.003 0.005 0.035	1.41 0.99 0.50	Rejected	Poor fit with Poisson and negative binomial
Model for AMT:							
$\ln(AMT_i) = -0.454 \times CE_i + 0.921 \times SEC_i^2 + 1.407 \times MGR_i + 0.988 \times \sqrt{ENG_i} + 0.495 \times \sqrt{BCW_i} - 0.774$							
exptd	0.0462	0.0003	None	-	-	Accepted	insignificant
breadth	0.3968	0.1453	SEC MGR ENG BCW	0.014 0.007 0.004 0.019	1.03 0.86 0.71 0.43	Rejected	Okay
Model for breadth:							
$\ln(breadth_i) = -0.418 \times CE_i + 1.033 \times SEC_i^2 + 0.858 \times MGR_i + 0.707 \times \sqrt{ENG_i} + 0.427 \times \sqrt{BCW_i} - 0.053$							
ratio	0.2110	-	CE SEC BCW	0.001 0.000 0.000	1.22 -1.35 -1.75	Rejected	Okay
Model for ims/sds							
$\sqrt{ratio}_i = -1.204 \times CE_i - 1.349 \times SEC_i^2 - 1.748 \times \sqrt{BCW_i} + 2.973$							
Key:				MGR – Functional Managers			
CE – Clerical Employees				ENG – Engineers			
SEC – Secretaries				BCW – Blue collar workers			

The Functional managers’ and engineers’ level of education was found to have the greatest impact on Ugandan firms’ integration of their hardware devices. Employee skills are seen to have a significant effect on the level of usage of systems, devices and stations in firms. Particularly the level of technical skills of the functional managers and blue collar workers are found to have a significantly positive impact on the acquisition of these technologies while clerical employees significantly impacted on sds negatively.

The variation in AMT was explained 43% of the time by employee skills. Functional managers, engineers and blue collar workers were found once again to impact positively on the adoption of advanced manufacturing technologies in general. Employee skills also significantly impacted on both the intensity of use and plans for future investment of AMT's explaining the variation 40% of the time. Technical skills of secretaries, functional managers, engineers and blue collar workers were all found to significantly and positively impact on this variable.

3.2 Role of internal/external influences on AMT adoption

Table 2 shows the results of regression of internal and external influences on AMT adoption:

Table 2: Summary of internal/external influences against dependant variables

Dependant variable	Pseudo-R ²	P-value gof	Significant variables	P-values	Coeff.	Null hypothesis	Model
User	0.2454	-	-	-	-	Accepted	Insignificant
Ims	0.2333	0.0024	MD ENG ENV	0.000 0.016 0.000	0.02 0.04 0.04	Rejected	Poor fit with poisson and negative binomial
Model							
$\ln(ims_i) = 0.017 \times MD^3_i + 0.040 \times ENG_i^2 + 0.010 \times MRT^2_i + 0.000 \times CUST^3 + 0.039 \times ENV^2 - 0.059 \times TAX^2 - 1.621$							
Sds	0.2615	0.0010	MD ENG ENV TAX	0.046 0.028 0.006 0.003	0.03 0.04 0.04 -0.05	Rejected	Poor fit with Poisson and negative binomial
Model							
$\ln(sds_i) = 0.029 \times MD^3_i + 0.042 \times ENG_i^2 + 0.022 \times MRT^2_i - 0.007 \times CUST^3 + 0.038 \times ENV^2 - 0.054 \times TAX^2 - 3.449$							
AMT	0.0997	-	MD ENG ENV	0.001 0.018 0.001	0.02 0.05 0.04	Rejected	Significant
Model							
$\ln(AMT_i) = 0.019 \times MD^3_i + 0.049 \times ENG_i^2 + 0.020 \times MRT^2_i - 0.004 \times CUST^3 + 0.041 \times ENV^2 - 0.016 \times TAX^2 - 1.589$							
expctd	0.1296	0.0034	TAX	0.010	0.05	Accepted	Insignificant
breadth	0.1115	-	MD ENG ENV	0.000 0.035 0.000	0.016 0.032 0.036	Rejected	Significant
Model							
$\ln(breadth_i) = 0.016 \times MD^3_i + 0.032 \times ENG_i^2 + 0.022 \times MRT^2_i - 0.006 \times CUST^3 + 0.036 \times ENV^2 - 0.007 \times TAX^2 - 0.66$							
Ratio	0.0278	-	none	-	-	Accepted	Insignificant
Key: MD – Managing Director (MD)/CEO ENG – Engineering/ Production departments MRT = Marketing/Sales department CUST= Customers ENV – Environmental, safety or health TAX – Tax incentives and/or favourable financing							

A high ratio of ims to sds indicates that firms' are integrating and therefore fully exploiting the capabilities of their SDS's. Employee skills were found to have an impact on this ratio explaining its variation 21% of the time. The higher the level of technical skills of clerical employees the more likely was there to be integration where as the higher the level of technical skills of secretaries and blue collar workers the less likely was there to be integration.

The results in table 2 show that internal and external influences have no impact on whether firms' use advanced manufacturing technologies or not. The Managing Director/CEO, engineering/production departments and environmental, safety or health concerns were found to impact significantly on the level of adoption of integrative and managerial systems in firms as well as the adoption of SDS's and AMT's while Tax incentives/favourable financing influenced SDS's negatively. Tax incentives and/or favourable financing were found to significantly to some extent influence firms' plans to invest in AMTs

The Managing Director/CEO, Engineering and production departments and Environmental issues positively influenced significantly current and future investments in AMT's. All internal and external influences were found to have no significant effect on firms' integrating their SDS's.

3.3 Contribution of strategic motivations to AMT adoption

The tabulation in Table 3 shows the summary of the results of regression of strategic motivations on AMT adoption.

Strategic motivations have no effect on users or non-users of AMT's as well as on the use of integrative and managerial systems save for the need to have a competitive advantage as was also the case with adoption of AMT's in general; current and future investments. Superior firm image and reduction in labour costs were found to significantly impact positively on firms' usage of SDS's. Reduction in labour cost affected significantly plans to invest in AMT's.

Increased quality of customer services and increased domestic market share had a negative impact on the integration of systems, devices and stations in firms. Only the need to increase the foreign market share had a positive impact on integration of system devices and stations

4.0 CONCLUSION AND RECOMMENDATIONS

In conclusion this study discovered that the technical skills levels' of the blue collar workers, functional managers and engineers is very instrumental in implementing hardware forms of AMT's. On the other hand the skills of the clerical employees are seen to be very instrument in integrating these technologies. This is a very important result especially since hitherto it would not seem strange for an industry to ignore the input from the blue collar worker and clerical staff in these processes. In general and as expected the education levels of the functional managers and engineers cannot be overlooked. It therefore underlines the importance in handling this process in such a way that these categories of employees feel that it has been a success and would be willing to try it again. Another interesting revelation is that customers and marketing and sales departments have no influence on any of the variables. This does not suggest that they are not important but simply they are not exclusive preoccupations of Ugandan firms. The CEO by far has the strongest influence closely followed by environmental issues.

Table 3: Summary of strategic motivations against dependant variables

Dependant variable	Pseudo-R ²	P-value gof	Significant variables	P-values	Coeff.	Null hypothesis	Model
User	1.0000	-	-	-	-	Accepted	Insignificant
Ims	0.0666	-	CPADV	0.049	0.571	Rejected	weak
Model							
$\ln(ims_i) = 0.006 \times PRDCT_i + 0.152 \times LBCT_i + 0.199 \times PRD_i - 0.010 \times PRDQT^2 - 0.475 \times \sqrt{CUSTSQ}$ $- 0.308 \times \frac{1}{\sqrt{DMRT}} + 0.006 \times FMRT^3 + 0.517 \times \ln(CPADV) + 0.023 \times FLX^2 + 0.203$							
Sds	0.2292	0.0001	LBCT CPADV	0.040 0.003	0.534 1.781	Rejected	Significant but Poor fit
Model							
$\ln(sds_i) = 0.151 \times PRDCT_i + 0.534 \times LBCT_i + 0.236 \times PRD_i + 0.011 \times PRDQT^2 - 0.761 \times \sqrt{CUSTSQ}$ $+ 0.492 \times \frac{1}{\sqrt{DMRT}} - 0.004 \times FMRT^3 + 1.781 \times \ln(CPADV) + 0.025 \times FLX^2 - 3.901$							
AMT	0.0586	-	CPADV	0.026	0.770	Rejected	Significant
Model							
$\ln(AMT_i) = 0.052 \times PRDCT_i + 0.240 \times LBCT_i + 0.253 \times PRD_i - 0.005 \times PRDQT^2 - 0.603 \times \sqrt{CUSTSQ}$ $- 0.320 \times \frac{1}{\sqrt{DMRT}} + 0.005 \times FMRT^3 + 0.770 \times \ln(CPADV) + 0.026 \times FLX^2 - 0.159$							
Expctd	0.1363	0.0014	LBCT	0.014	-0.377	Rejected	Significant but poor fit
Model							
$\ln(expctd_i) = 0.116 \times PRDCT_i - 0.377 \times LBCT_i + 0.007 \times PRD_i - 0.001 \times PRDQT^2 - 0.803 \times \sqrt{CUSTSQ}$ $+ 1.380 \times \frac{1}{\sqrt{DMRT}} + 0.008 \times FMRT^3 - 0.089 \times \ln(CPADV) - 0.010 \times FLX^2 + 1.133$							
Breadth	0.1491	0.0000	CPADV	0.009	0.592	Rejected	Significant but poor fit
Model							
$\ln(breadth_i) = 0.085 \times PRDCT_i + 0.083 \times LBCT_i + 0.158 \times PRD_i - 0.011 \times PRDQT^2 - 0.490 \times \sqrt{CUSTSQ}$ $+ 0.244 \times \frac{1}{\sqrt{DMRT}} + 0.004 \times FMRT^3 + 0.593 \times \ln(CPADV) + 0.016 \times FLX^2 + 0.665$							
Ratio	0.1674	-	CUSTSQ DMRT FMRT	0.050 0.009 0.016	-1.140 -2.817 0.012	Rejected	Okay
Model							
$\sqrt{ratio_i} = -0.240 \times PRDCT_i + 0.089 \times LBCT_i - 0.044 \times PRD_i - 0.056 \times PRDQT^2 - 1.140 \times \sqrt{CUSTSQ}$ $- 2.817 \times \frac{1}{\sqrt{DMRT}} + 0.012 \times FMRT^3 - 0.547 \times \ln(CPADV) + 0.030 \times FLX^2 + 7.235$							
<p>Key:</p> <p>PRDCT = firm response to reduction in cost of finished goods LBCT = reduction in labour costs PRD = firm response to increase in overall productivity PRDQT = firm response to increased quality of product(s)</p> <p>CUSTSQ = increased quality of customers services DMRT = increased domestic market share FMRT = increased foreign market share CPADV = superior firm image FLX = firm response to increase in the flexibility of the manufacturing process</p>							

The strongest single strategic motivation that seems to drive Ugandan firm to invest in AMT's appears to be the superior image of the firm followed by reduction in labour costs. Apparently firms look keen on having a competitive advantage over their rivals in industry. Quality of customer services, increased domestic and foreign market share are the driving factors that force companies to integrate their systems devices and stations.

The results of this study present interesting insights into the predictors of AMT penetration in a developing country like Uganda. The study may need to be expanded to include a larger sample such that ordinary linear regression methods may become applicable. This certainly is a potentially rich area of research for policy makers, industry and academics.

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