MAKERERE UNIVERSITY

DEGREE OF AUTOMATION IN THE MACHINE TOOL DRIVEN MANUFACTURING INDUSTRY IN DEVELOPING COUNTRIES – THE CASE OF UGANDA

by

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A Thesis Submitted to the School of Graduate Studies in Partial Fulfilment of the Requirements for the Award of the Degree of Doctor of Philosophy of Makerere University

DECLARATION/CERTIFICATE OF ORIGINALITY

This is to certify that this thesis is original, my own unaided work and has not been published and/or submitted for any other award or to any other University before.

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The thesis has been submitted for examination with the approval of the following supervisor

Assoc. Prof. M.A. Okure – Makerere University

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Date: …………………………………………………………….

DEDICATION

This thesis is dedicated to my close family

ACKNOWLEDGEMENT

This study was fully funded by the NUFU/FOT project funded by the Norwegian Government designed to build capacity at Makerere University. I therefore extend my foremost gratitude to the Norwegian Government together with Prof. Tore Haavaldsen of University of Trondheim and Prof. J.A. Mwakali of Makerere University who coordinated the project.

I am greatly indebted to my supervisor Assoc. Prof M.A. Okure for all the advice academic and otherwise he willingly provided. I sincerely thank him for the time spent in reviewing this work.

I humbly express my gratitude to all the companies that accepted to actively participate in this study. Not forgetting members of staff from the institute of statistics, Makerere University who provided assistance whenever called upon.

I wish also to extend my gratitude to all my colleagues in the Department of Mechanical Engineering who provided me with moral support to complete this study. I humbly request for forgiveness from any of you I may have offended during these trying moments. Please take heart since the results are now evident.

Lastly I am greatly indebted to my immediately family for its patience. Special thanks are accorded to Victoria, Romeo, Erniel, Maria Louisa and Condelezza. I hope this study will not be in vain but make a contribution to our society.

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ACRONYMS

AIC	-	Alkaike information criteria
AID	-	Automated identification stations
AIN	-	Automated inspection station
AMHD	-	Automated material handling devices
AMT	–	Advanced Manufacturing Technology
CAD	–	Computer Aided Design
CAD/E	–	Computer Aided Design and Engineering
CAM	–	Computer Aided Manufacturing
CAPE	–	Computer Aided Production Engineering
CAPP	–	Computer Aided Process Planning
CAT	-	Computer aided testing/inspection
CEO	-	Chief Executive Officer
CIM	–	Computer Integrated Manufacturing
COMESA	–	Common Market for Eastern and Southern Africa
CNC	–	Computer Numerical Control
CRP	–	Capacity Requirements Planning
DCF	-	Discounted cash flow
EAC	–	East African Community
EDM	-	Engineering data management
FA	–	Flexible Automation
FDI	–	Direct Foreign Investment
FILP	-	Fiscal Investment and Loan Program
FMS	–	Flexible Manufacturing Systems
FP	-	Fractional polynomial
GDP	-	Gross domestic product
G.0.F	-	Goodness-of-fit after Poisson regression
GT	–	Group Technology

ICT	–	Information and Communications Technology
IIP	-	Index of Industrial Production
IMS	–	Integrative and managerial systems
IPR	–	Intellectual Property Rights
irr	-	Incident rate ratio
JIT	–	Just In Time
LAN	-	Local area networks management software
MD	-	Managing Director
MFP	-	Multivariable fractional polynomial
MFPED	-	Ministry of finance planning and economic development
MRP	–	Material Requirements Planning
MRPII	–	Material Resources Planning
MTCS	–	Medium Term Competitive Strategy
nbreg	-	Negative binomial regression
NC	-	Numerical control
NRM	–	National Resistance Movement
OLS	-	Ordinary Linear Squares
PLC	-	Programmable controllers
PPIC	-	Production planning/inventory control
prtest	-	Group proportional test
p-value	-	probability value
R&D	–	Research and Development
RAA	–	Revealed Absorptive Advantage
RBT	-	Robots
RCA	–	Revealed Comparative Advantage
ROI	-	Return on Investment
RPA	–	Revealed Publication Advantage
RTA	–	Revealed Technology Advantage
SDS	–	Systems, devices and stations
SME	–	Small and Medium Enterprises
SPC	-	Statistical process control
SPCS	-	Shop-floor control systems

ttest	-	Group mean comparison test
TWG	–	Technical Working Group
UMA	–	Uganda Manufacturers Association
UBOS	–	Uganda Bureau of Statistics
UK	-	United Kingdom
US	-	United States of America
USSIA	–	Uganda Small Scale Industries Association
VAT	-	Value Added Tax
WAN	-	Wide area networks management software
WTO	-	World Trade Organisation

ABSTRACT

Developing countries like Uganda are characterised by small domestic markets, weak laws on intellectual property rights and poor labour legislation. In addition, lack of awareness, poor industrial strategy, no external markets to complement the domestic one, high tool investment costs and low returns can be cited as bottlenecks to the growth of the manufacturing industry. The industry is further characterised by small-medium batch sizes and non-flow line production technologies, low volume/capacity, lack of high responsiveness, limited potential of industrialization and therefore cannot survive in highly competitive markets.

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 sets of predictor variables most of which are intangible. The study is carried out in 39 firms found to be using machine tools and employ more than five people. Non parametric statistical techniques, logistic, quantile and linear regression together with Multivariate fractional polynomial techniques were used. In all cases robust regression was applied.

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 were instrumental in integrating these technologies. The 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.

Lastly, recommendations were made for Government, industry and the academia. The study provides interesting insights into factors that characterize this industry in a developing country.

CHAPTER ONE: INTRODUCTION

1.1 Background

Policy trends in developing countries are progressively shifting from inward looking policies namely; restriction of technology inflow and direct foreign investment (FDI), protection from competing imports, over-valued exchange rates and industrial licensing regimes to outward looking trade *oriented* and market responsive regimes (Katrak, 2000). Uganda under the National Resistance Movement (NRM) government has been no exception with major economic reforms beginning in the mid-1980s.

These reforms have had a general impact on the economy with annual growth rates of gross domestic product (GDP) rising from 3.1% in 1991/92 to 5.0% in 2000/01 with a peak of 10.6% in 1994/95 (MFPED, 2001). However, provisional Index of Industrial Production (IIP) data, which is a quick indicator of trends in the manufacturing sector, showed a downward trend for the years 1997 to 2000 from 17.6% to 1.5% and then rose to 8.4% in 2002 (UBOS, 2004). This re-based index covered 19 establishments that shared 48.7% of value added of the formal manufacturing sector and had fiscal year 1997/98 as its base period. MFPED (2001), noted that of major concern in the manufacturing sector was its lack of international competitiveness.

In the year 2002 expenditure on major imported commodities stood as follows Petroleum, petroleum products and related materials (US $ 173.8 million), Road vehicles (US $ 105.1 million), Cereal and cereal preparations (US $ 73 million), Iron and steel (US $ 55.5 million) and Medical and pharmaceutical products (US $ 48.2 million). Iron and steel though having taken the fourth largest share of expenditure for the years 2000 to 2002, was attributed to the rapid growth in the construction sector and not as a result of an input to the manufacturing sector (UBOS, 2003). In addition among these five major imported commodities only iron and steel is categorised as "Intermediate materials" with the rest being categorised as "consumer goods" (Petroleum and cereals) and capital goods (Road vehicles), others (medical and pharmaceutical products) and none was in the category of raw materials (UBOS, 2003). This phenomenon indicates the relatively poor performance of the manufacturing sector in Uganda.

With respect to commodity export performance coffee remained the major foreign exchange earner in the year 2002 contributing a proportional share of 20.7 % earning US $ 96.6 million from 201,591 tons. Other major export earners included Fish and fish products (20.4% earning US $ 89.9 million), Gold (14% US $ 60.3 million), Tobacco (10.3% US $ 44.6 million), Tea (7.2% US $ 31.2 million), Flowers (4.1% US $ 17.8 million), electric current (3.6% US $ 15.6 million) and Cotton (2.2 % US $ 9.5 million). These seven major exports took a total share of 75.2% of all Uganda's exports (UBOS, 2003). See Figure 1 for comparison to other countries.

The foregoing statistics in addition to showing the lack of international competitiveness as contended in MFPED (2001), also indicates inadequate national competitiveness and a limp manufacturing sector in Uganda. In the year 2001 there were 202 establishments recorded countrywide in the manufacturing sector contributing to the IIP of which 19 were in the steel and steel products category. Other groups include food processing (57), tobacco and beverages (14), textiles and clothing (13), leather and footwear (8), timber, paper and printing (27), chemicals, paint and soap (25), bricks and cement (14) and miscellaneous (25) (MFPED, 2001).

The prosperity of any nation is dependent on the availability of raw materials and/or the productivity of its people. With respect to productivity the machine tool industry has for decades taken the centre stage of the machine driven production of all industrialized countries. In the developed world, manufacturing companies invest heavily in Computer Numerical Control (CNC) machine tools and related flexible automation to enhance their competitiveness through a range of improvements in production processes as well as reduce costs related to expensive labour.

Uganda's manufacturing industry is generally characterised by stagnation in 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. The increasing scales that emerged with industrialization world wide restricted the establishment of machine tool production facilities due to the small size of the Ugandan domestic market in effect limiting the potential of industrialization. Small batch production may have its advantages with regards to customising however creativity and flexibility of production become essential components of the system.

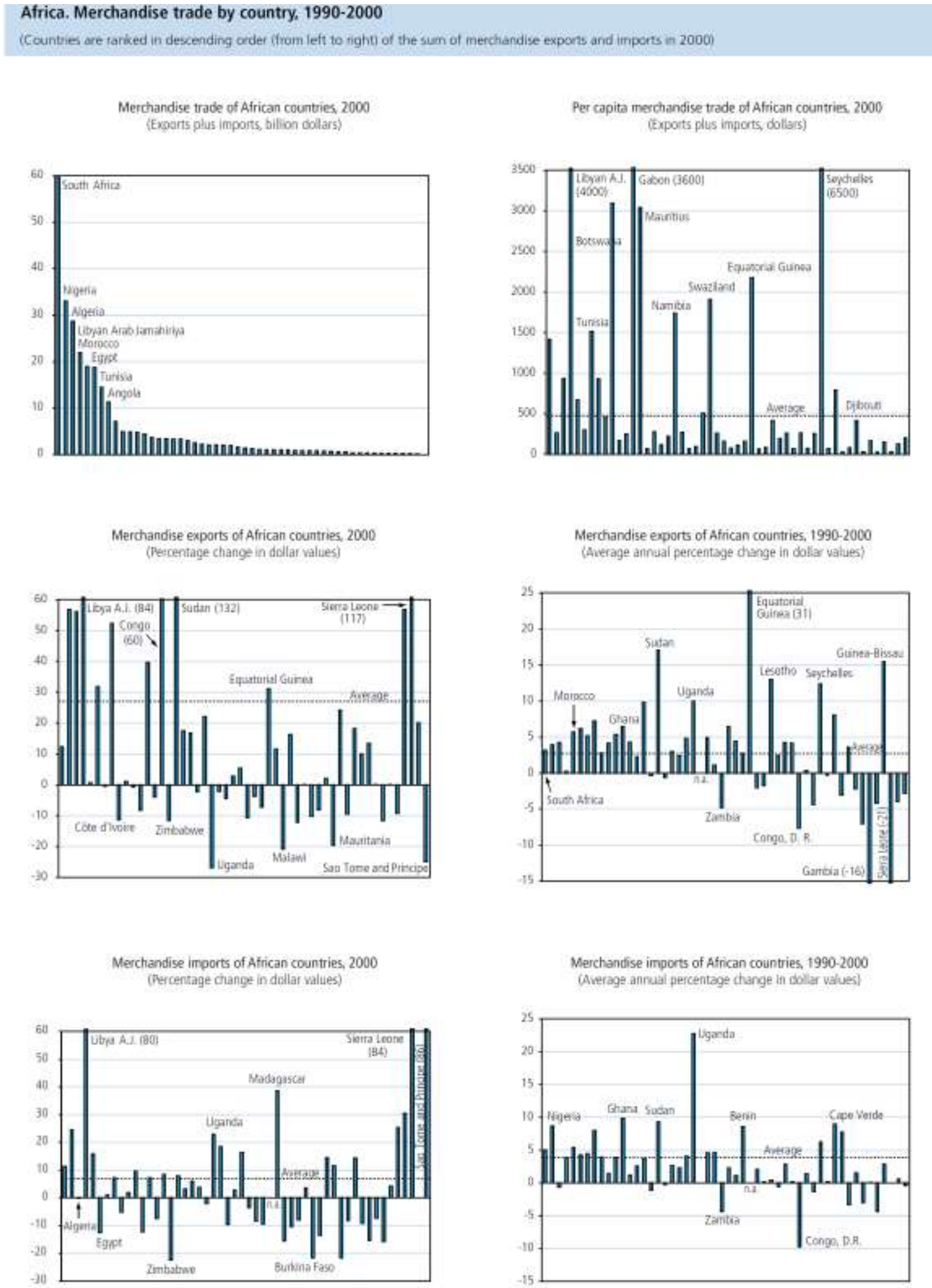

Figure 1: Trade statistics of other African countries compared to Uganda

(Source: International Trade statistics (WTO, 2001))

Successful global competitors now are rejecting the “traditional” manufacturing paradigm of tradeoffs among and between competitive priorities such as low cost, time, quality and flexibility (Mechling, Pearce, & Busbin, 1995). Small manufacturing firms far outnumber large manufacturing firms, employ a substantial majority of the manufacturing employees in the United States of America (US), and play a critical role in contributing to the vitality of the US economy (Troy, 1990 as cited in Mechling et. al. 1995).

Small and medium enterprises (SME’s), although still an under investigated field of research, are increasingly recognized for their major role in the economy: they represent an important proportion of operating firms in most industrialized countries, (Bannock & Daly, 1994; as cited in L. A. Lefebvre, Lefebvre, & Harvey, 1996), they contribute significantly to new job creation (Chittenden, Robertson, & Watkins, 1993; as cited in L. A. Lefebvre, Lefebvre, & Harvey, 1996), and to innovative activities, (Acs & Audretsch, 1998; as cited in L. A. Lefebvre, Lefebvre, & Harvey, 1996), and they have been shown to be increasingly active in export markets (Bonaccorsi, 1992; Samuels, Greenfield, & Mpoku, 1992).

The majority of businesses are owner-managed small businesses, and they are an important source of new jobs. Small businesses accounted for 99% of the United Kingdom’s (UK’s) businesses in 2002, 56% of the employment and 52% of UK turnover (*Government Action Plan*, 2004). Dale and Morgan (2001), found that 85% of new jobs created between 1995 and 1999 were in small businesses. Small businesses are therefore an important source of employment, contribute to the local economy and are at the forefront of the government’s aim to encourage entrepreneurship and indigenous businesses (as cited in Fuller-Love, 2006).

Birley and Niktari (1995), found that, in the opinion of accountants and bank managers, 70% of small business failures were due to a very large extent to being under-capitalized, to short-term liquidity problems or insufficient working capital. These problems were compounded by ‘A lack of management experience on the part of the owner-managers in 80% of the cases’. Other reasons for small-firm failure included lack of sales and over-reliance on one or two customers (Natwest, 1997 as cited in Fuller-Love, 2006).

The slow or non-existent uptake of Advanced Manufacturing Technologies (AMT's) and its attendant Computer Integrated Manufacturing (CIM) may be attributed to the view in industry which considers this issue parochial, simplistic and limiting resulting in widespread confusion and misunderstanding concerning this subject. The extent to which there exists technical, financial and market infrastructures to support this trend is not clear. Gerwin (1988), states that lack of understanding of radical new computer related manufacturing technologies and their implications are significant barriers to their diffusion and computerised technology is characterised by extreme technical complexity. The characteristics of many entrepreneurs, especially their autocratic management style, limited objectives, lack of resources and suspicion of 'specialist' management mean that they find it difficult to build a management team that can take the business into the next growth stage (Wynarczyk, Watson, Storey, Short, & Keasey, 1993 as cited in Fuller-Love, 2006).

The opening up of new markets and emergence of new competitors depicts the changing face of today's manufacturing. New products result from new technologies which in turn require new production techniques and appropriate management control systems. Global competition only serves to accelerate these rates of change. The aphorism 'change' or 'perish', results from this phenomenon. Therefore, evolving a strategy for the manufacturing industry in Uganda will require adding more value to its products by either technical inventiveness or commercial acumen. This includes improving functionality of existing products, improving quality, introducing more efficient production processes, collaboration with domestic and foreign firms, improved procurement and logistics, embedded new services and so on.

Industry expects any investment in AMT to pay back in a relatively short period of four to five years. Therefore, the expression related to time is not taken into account in the decision problem. However, AMT's with its attendant CIM 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, competitive advantage etc. Traditional appraisal methods such as payback, internal rate of return and discounted cash flow (DCF) are thus rendered inappropriate for decision making. The benefits of AMT are both tangible and intangible and depend on the particular AMT and its application (Schroder & Sohal, 1999). A strategic management with a short term policy orientation will attempt to avoid uncertainty by stressing a short run time horizon, financial control, and profit maximization in decision making. Return on investment (ROI), payback, and other quantitative financial criteria will predominate as is the current situation for many American firms especially in autos and steel (Gerwin, 1988). Observations have also been made to the effect that manufacturing innovation produced an overall trend toward increasing the controllability of operations (Bessant & Dickson, 1982; as cited in Gerwin, 1988).

Alternatively, a strategic management with a *long term policy orientation* will attempt to live with uncertainty by emphasizing a long run time horizon, adaptive planning, and minimizing the chances of disaster. This seems to be the situation for many Japanese and German manufacturing companies (Hayes & Abernathy, 1980 as cited in Gerwin, 1988). Since capital investment decisions will be based on long run qualitative considerations, computerized technology will be in a better position to be adopted. Ettlie's (1983), finding that possessing a long range technological policy stimulates radical process innovation in a firm is consistent with this observation.

Prevailing financial and technical uncertainty leads strategic managements with a short-term orientation to depend upon quantitative financial evaluation techniques. With future net returns difficult to predict and hard to control, acquisition cost assumes a key role in discounted cash flow or payback calculations. In short managements which value control and efficiency will adopt a short run orientation, while those which value adaptation and viability will opt for a long term orientation (Gerwin, 1988).

In their study with South African Manufacturers Sohal, Schroder, Uliana and Maguire (2001), showed that the use of discounted cash flow, ROI (undiscounted) and sensitivity analysis did not significantly differ across the type of AMT invested in (computer hardware, software and plant and equipment). However, there were differences in the use of payback as a financial evaluation technique across the three AMT investment types they studied ($\chi^2 = 7.12$, df = 2, $p < 0.05$). In addition companies that invested in AMT plant and equipment were proportionally less likely to use the payback evaluation technique than companies that invested in computer hardware and software .

The analytical framework of this research is based on the technological systems approach originally defined by (Carlsson & Stankiewicz, 1991; as cited in Sung & Carlsson, 2003), as "network(s) of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilise technology". The technological system is not static but evolves with alterations in the contents of its components as well as in the relationships among actors and institutions. Attainment of a vibrant machine tool industry as a technological system requires careful nurturing through three distinct stages; i) An embryoic or generation stage where a ‘critical mass’ is necessary. This is the stage before the first commercial application of new products. ii) An infant stage where innovation and development of products takes place. Here the first commercial applications enter the market and iii) An adolescent stage where diffusion of the products takes place, finds a multitude of applications and the industry becomes self-sustaining (Sung & Carlsson, 2003).

It follows that policy by government in collaboration with industry and research institutions for a sustainable machine tool driven manufacturing industry in Uganda needs to be geared towards reducing the learning period for the local industry. Identifying, inducing and facilitating a ‘critical mass’ with considerable mobilisation and financial abilities, as a champion of the cause into this industry would be a vital goal for policy. Policy measures in research and development (R&D) as well as motivation for enhanced technological capabilities such as an “industrial policy to nurture strategic industries” need to be considered. Last but not least, policy should be geared towards achieving success in foreign markets.

1.2 Statement of the Problem

In Uganda the growth of the machine tool driven manufacturing industry appears to have stagnated. While the size of the domestic market is too small to support mass production in this industry, the industry lacks the prerequisite competitiveness to tap into foreign markets. The general trend worldwide to achieve efficiency and utilisation levels of mass production, while retaining the flexibility that job shops have in batch production through AMT’s has not taken root in Uganda.

Government policies at the moment are not conducive enough to foster a steady growth of this industry. In addition, lack of awareness, poor industrial strategy, no external markets to complement the domestic one, high tool investment costs and low returns can be cited as bottlenecks to the growth of the industry. The industry is further characterised by small-medium batch sizes and non-flow line production technologies, low volume/capacity, lack of high responsiveness, limited potential of industrialization and therefore cannot survive in highly competitive markets.

The effect education levels and technical skills have on the performance of this industry in Uganda has never been documented. The main incentives for AMT adoption in existence among Ugandan manufacturing firms are not known. The types and degree of automation appropriate to the various categories of establishments in Uganda is not known. The main objectives and strategies of the Ugandan machine tool driven manufacturing industry do not seem to be conducive to acquisition of AMT's.

This research aims at generating models that take into account the existing environment with a view to catalyse technological growth in the machine tool driven manufacturing industry in Uganda.

1.3 Objectives

The main objective of the research was to develop models to guide government and local industry in policy and strategic decisions relevant to realising technological growth in the machine tool driven manufacturing industry in Uganda.

The specific objectives were:

- To develop robust indicators that measure the depth of penetration and/or utilization of AMT's in industry.
- To identify actors, factors and constraints that influence technological growth among Ugandan machine tool driven firms.
- To develop relationships between the depth of penetration and/or utilization of AMT's in industry and these actors, factors and constraints.
- To identify, define and develop means to influence these actors, factors and constraints.
- To validate the resultant models through stakeholder opinion.

1.4 Research questions and Hypotheses

This study addresses the following four research questions concerning manufacturing firms in Uganda: What is the relationship between level of education of employees and the utilization of AMT's? How do internal and external proponents influence AMT adoption trends? How does the firm structure affect AMT penetration? Which strategies employed by firms are central to automation levels?

To address these questions, six hypotheses concerning manufacturing firms in Uganda are proposed:

H_{01}: Technical skills of all groups of employees have no positive effect on the level of automation in the Ugandan machine tool driven industry.

H_{02}: Influences of internal and external proponents are not determinants of the level of automation in the Ugandan machine tool driven industry.

H_{03}: There is no relationship between the firm configuration and the degree of automation in Ugandan firms.

H_{04}: There is no positive relationship between production strategies and the degree of automation within Ugandan machine tool driven firms.

H_{05}: The interaction between production strategy and technological skills of employees of Ugandan firms are not determinants for the degree of automation.

H_{06}: Influences of proponents do not modify the form of the relationship between degree of automation and technical skills of employees in firms.

Hypothesis 1 relates to the first research question, hypothesis 2 relates to the second research question, hypothesis 3 relates to the third research question, hypothesis 4 relates to the fourth research question and hypotheses 5 and 6 relate to the first, second and fourth research questions

1.5 Applicability of research findings

With increasing global competition among manufacturers, the role of advanced manufacturing technologies in assisting firms to maintain their competitive edge cannot be overlooked. A strong machine tool industrial base is more or less a prerequisite for industrialisation since it is the backbone for the manufacturing sector through the provision of spare parts, maintenance facilities as well as a host of other useful products. There is therefore a need to improve the performance of the machine tool driven manufacturing industry in Uganda by carrying out research to boost its capacity and quality. This will in the short run lessen the dependency on imported goods and spare parts and ultimately provide a vibrant as well as dynamic industry that can evolve as technology develops.

Identification of achievable financial, technical and strategic objectives in order to encourage investment in AMT's for the local machine tool industry would warranty

- Increased revenue and profits through increased sales in local markets, sales to external markets, cost reduction and increased economies of scale and scope.
- Concrete technical benefits accruing from cost reduction, increased possibilities of outsourcing, upgrading the technological level of the product chain, improved quality of product and improved technological capability.
- Espousing strategic opportunities such as improved competitiveness in local industry and gaining access to regional and world markets.

This study presents a methodological framework that can be replicated in any setting. The method takes into account the underlying unique parameters that characterize the industry and offers a practical approach of analysis that can better inform policy.

1.6 Conceptual Framework

The overall framework used in this study is clearly presented and is easy to conceptualise (see Figure 2). It identifies the structures, actors, interactions and knowledge frames that are operationalised during the course of this research. The outcome variable operationalised during the study is the depth of penetration/utilisation of AMT's. This dependent variable is indirectly influenced by the independent variables that stem from the industrial organisational setup and comprise of the actors, factors and constraints that determine the adoption trends of AMT's in industry.

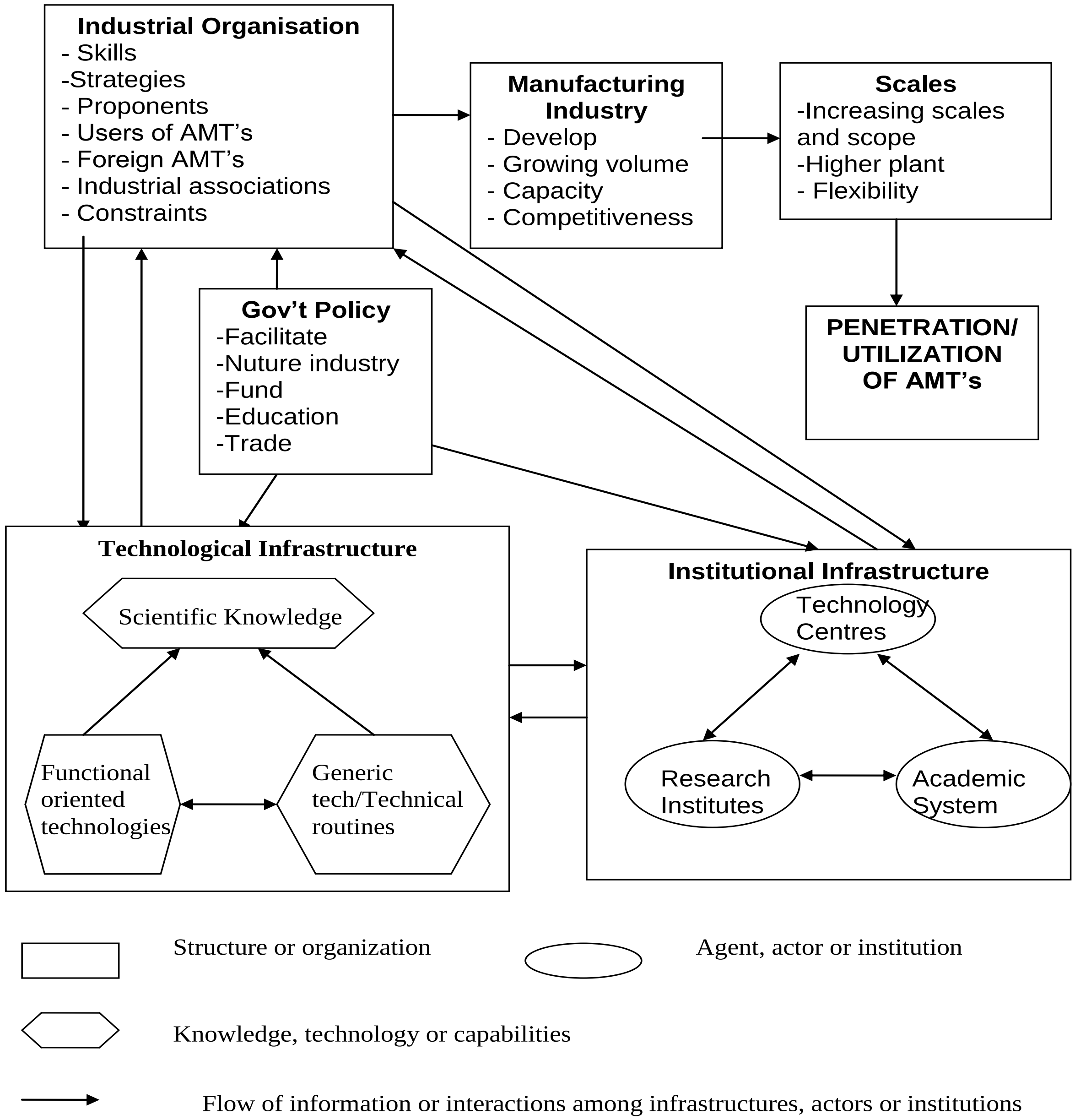

Figure 2: Conceptual Framework

The conceptual framework shows that the study informs government policy organs about interventions that can be taken at the macro-level that improve performance in this crucial sector. These interventions are geared towards development of the manufacturing sector by means of increased scales and scope, greater plant flexibility and overall competitiveness.

The study takes into account the existence of the wider picture comprising of both the institutional and technological infrastructure with a view of attaining the overall goal of increased utilization of AMT’s.

1.7 Scope

The study targeted manufacturing companies in Uganda that employ five or more personnel and have machine tools in their facilities. It encompassed all forms of AMT related software and hardware technology namely: computer aided design/engineering (CAD/E), computer aided process planning (CAPP), computer aided testing/inspection, statistical process control (SPC), computer aided testing/inspection (CAT), computer aided manufacturing (CAM), materials requirements planning (MRP), manufacturing requirements planning (MRPII), production planning/inventory control (PPIC), local area networks management software (LAN), wide area networks management software (WAN), group technology (GT), engineering data management (EDM), automated identification stations (AID), automated inspection station (AIN), automated material handling devices (AMHD), computer aided design workstations (CAD), computerized numerical control machine tools (CNC), numerical control machine tools (NC), programmable controllers (PLC), robots (RBT) and shop-floor control systems (SPCS) among others, taking into account their appropriateness to Uganda’s machine tool driven manufacturing industry. The study concentrated on efficacious methods of producing more or less customized variants of standardized products.

Due to time constraints, validation of the models is limited to soft validation techniques that compare the results of the study with opinion obtained from experts in academia and industry.

1.8 Scientific innovations

This study provides a tool the results of which policy can use as a basis to make systematic and informed decisions to direct the trend of AMT adoption in Uganda. Innovative indicators to measure technological growth are suggested and demonstrated.

In previous studies, small firms typical to the ones found in Uganda, have been investigated in the developed nations (Baldwin & Johnson, 1999; Bourgeois & Eisenhardt, 1988; Chittenden et. al., 1993; E. Lefebvre & Lefebvre, 1992; Mechling et. al., 1995; J. Meredith, 1987; Rischel & Burns, 1997; Samuels et. al., 1992; Sohal et. al., 2001). However, the author knows of no research that has specifically studied AMT adoption patterns in Uganda.

The results present interesting and unique features that can influence industry and government policy into making informed decisions regarding this crucial sector.

1.9 Thesis Layout

The thesis is divided into six chapters, the bibliography and appendices. Chapter one provides the introduction and presents the background to the study, the research problem that is addressed, the objectives, the research questions and null hypotheses tested, significance of the study, conceptual framework and scope of the study. Lastly, the summary layout of the thesis is presented.

Chapter two presents the literature review. This chapter cites past studies related to AMT’s in both developing and developed countries. The status to the background is presented and various methodological issues used in previous studies are critiqued. The chapter ends with a conclusion that identifies the existing gaps in the literature and establishes the basis for the need for this research.

Chapter three presents the methodology used to test the hypotheses. The research variables, their operational measures and the data collection procedures are described. It describes the design of the study and introduces the model variables including the techniques used in variable operationalisation. Lastly, the method used to interpret the models as well as the pre- and post-diagnostic regression techniques are elucidated.

Chapter four presents the empirical results of this study. The pre-regression validation results, both visual and analytical, are first presented. The models are then presented together with their post-regression validation results. In this chapter, reference is continuously made to the appendices where detailed results of the models are obtainable.

Chapter five discusses the empirical results and acknowledges the research limitations of this study. The factors affecting the different measures of AMT penetration trends' are clearly spelt out. Finally, moderating roles of the independent variables are isolated and a summary of the discussion is presented.

Chapter six provides the conclusion, implications and avenues for future research. The Author concludes this chapter with recommendations on interventions that can be taken by governments, industry and academia towards fostering the manufacturing industry in developing countries.

The appendices are divided into three parts: Appendix 1 presents the primary survey instrument, appendices 2 through to 7 present the raw data obtained while appendix 8 presents the tables of results of analyses. Finally in appendix 9 the validation questionnaire is presented.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Five to seven million years ago our human ancestors were, we presume, still sitting in the tree. Three million years later we were standing upright, using simple stone tools. Two million years later we were still using stone tools, though somewhat improved. Along the way we discovered fire, and some of us began to bury our dead. The world changed slowly then, and whatever inventiveness these early peoples may be said to have had, it was a pale shadow of what was to come.

Then, suddenly 40 to 50 thousand years ago – within less than 1% of the span of human existence – something happened to humans, perhaps as a minute gene change. Whatever it was, at this time creativity took off, as evidenced by specialized and compound tools, fabricated dwellings, and magnificent cave art. The material record in succeeding millennia then shows more or less continuous progression of such creative works, culminating in the birth of agriculture and cities some 10,000 years ago and the profusion of technology, art and science that has followed in the years up to the present (*Enhancing inventiveness for quality of life, competitiveness and sustainability*, 2004)

Mechling *et al*. (1995) identifies the following factors that have forced US manufacturers to make dramatic changes in their products, markets, and manufacturing strategies:

- slowdowns in economic growth have intensified competition for market share;
- saturated markets in many foreign countries have shifted emphasis abroad;
- the increasing capabilities of producers to appeal to consumer appetites for change are shortening product life cycles;
- the rate of technological transfer from development to product, and across products and markets is accelerating;
- Perhaps most importantly, the international competitive environment continues to intensify.

Taken together they note, these factors create a competitive environment which demands a transformation by many manufacturers in how they respond to rapidly changing global markets

The need for innovation in Uganda's manufacturing industry cannot be more emphasised by the statement with regard to VAT performance for the 2000/01 fiscal year; "Overall VAT did not perform well due to low collections from excisable goods and imports. Given the poor sales of local excisable goods VAT on these goods under-performed by 10.9%." (MFPED, 2001).

Following a series of workshops held during the calendar year 2003 and culminating with an "Invention Assembly" on April 23, 2004 at the National Academy of Sciences in Washington, DC, a report was issued by the Committee for Invention containing their collective findings and recommendations to policy makers. This committee noted that the lowering cost of design manufacture, transportation and communication had resulted in niche markets that represented large opportunities for products and services devised by the inventive mind. Further, they note, the emergence of high-speed worldwide communications and transport had also created an unprecedented global environment for knowledge sharing, distance learning and collaboration (*Enhancing inventiveness for quality of life, competitiveness and sustainability*, 2004).

The Government of Uganda seems to be aware of this shift as evidenced in the Background to the Budget (2001), whose theme is "Enhancing Economic Growth and Structural Transformation". This document in addition to placing emphasis on agriculture and agro-industrial exports also projects highest growth in the transport and communications sector. However, the role of the Ugandan Manufacturing industry as a key industry for economic growth is to some extent overlooked. It nonetheless notes "Of major concern in the manufacturing sector is its lack of international competitiveness" (MFPED, 2001).

> The sector (Manufacturing and Industry) is estimated to have grown by 2.4% which, though higher than the rate achieved the previous year (1999/2000), constitutes a decline compared to the growth levels in 1998/99. The poor performance is a reflection of the effects of the worsening terms of trade. As much of the manufacturing sector provides goods for the domestic market but relies heavily on imported inputs, a real exchange rate depreciation squeezes profitability in the sector. The sector can only maintain profitability by becoming more efficient, source a larger share of its inputs from domestic sources, or by selling a larger share of its output on export markets (MFPED, 2001).

This statement reinforces the argument that Government is conscious that the manufacturing sector needs to break into the international market to survive. Worth noting is that the growth in the transport and communications sector was recorded as 35% in the 2000/01 fiscal year, the expansion being attributed to mobile cellular, internet and fixed telephone services (MFPED, 2001).

In the US for example mass production was the order of the day, from the 1940s to the 1970s and the manufacturing strategy in firms focused on a limited number of products and made their margins from cost economies of scale. The crisis for US manufacturers was a dramatic slowing of domestic population growth, accompanied by continued growth of a diverse and fragmented global population (Mechling et. al., 1995). The US firms therefore were forced to compete in multiple markets, supplying multiple products.

In Uganda, government attempted to identify strategic areas with high growth potential in which the country could have a comparative advantage. Following wider consultations with major stakeholders in the policy formulation process to identify concrete actions that need to be undertaken to stimulate growth and boost the country’s exports, it went ahead to define the priority policy options and areas of intervention in the short to medium term. One such meeting was an Open Forum on the Economy that was jointly organised with the parliament.

> This forum appreciated that Government has an important role to play in supporting investment in strategic sectors of the economy in areas such as coffee, cotton, tea, fish, beef, hides & skins, and horticultural products. In addition higher education, Information and Communication Technology and specialised medical facilities are areas for further intervention (MFPED, 2001).

Notably neither the machine tool industry nor the metal industries were considered strategic enough to warrant government intervention.

This chapter focuses on the pertinent research to modelling factors influencing adoption and penetration of AMTs’ in Uganda.

2.2 Operationalisation of Models

Petra and Koenraad (2006), define a business model as a construct that mediates the value creation process, by selecting and filtering technologies and ideas, and packaging them into particular configurations to be offered to a chosen target market. Especially for new technology-based firms defining an appropriate business model from the beginning is difficult, and adaptation of the initial business model is therefore crucial for success.

2.3 Modelling Dependant Variables

In a multiple regression approach a dependent variable would be used to measure the level of AMT penetration in the Ugandan manufacturing industry. A small market cannot sustain a high scale of production and would thereby limit the majority of industries to operating as small scale industries. These industries may however strive favourably if they took on the option of high scopes of production which require both increased innovativeness and variability of products. Technologies expected to be acquired in the near future may be incorporated as well. The dependent variables can then be manipulated to make the model more robust.

Mechling *et.al.* (1995), measured 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) .

Baldwin and Lin (2002), used four different measures of technological activity to test the robustness of the hypothesis that "impediments are higher in more technological advanced or more innovative firms".

The first is USER—whether the plant uses advanced technology in the production process at all. This is a dichotomous variable taking a value of 1, if the plant uses any of the 22 technologies and 0, otherwise. This measure distinguished technology users from non-users but does not take into account the intensity of technology use.

The second—TECHUSE—measured the total number of advanced technologies in use. This is a continuous variable, similar to the one used by Mechling *et. al.* (1995), reflecting the total number of advanced technologies that a firm used and it ranged in value from 0 to 22. This measure took into account the intensity of technology use. Its form imposed a monotonic relationship between the number of technologies in use and the probability of reporting an impediment.

The third dependent variable consisted of a set of binary variables capturing different intensities—0, 1–4, 5–9 and more than 10 technologies. This measure took into account the intensity of technology use and it allowed for the possibility of a non-linear impact of the number of technologies that were used (Baldwin & Lin, 2002).

Lefebvre *et. al.* (1996), used three steps to determine the level of technological penetration. First of all, a dichotomous variable was used to identify AMT's adopted and implemented by firms. Secondly, a panel of 20 experts was asked to evaluate the degree of radicalness of each AMT for 13 different broad industrial sectors. The degree of radicalness being measured along a continuum where the radical nature of each AMT considered in each broad industrial sector was defined as "radical and revolutionary changes, clear departure from existing practices" whereas "incremental" was defined as "minor changes and minor improvements." The experts comprised of four from the academic sector, six from the public or parapublic sector, and ten from the private sector and were contacted in person. Thirdly, the range of potential use of each AMT was determined across 13 broad industrial sectors. This was done by closely examining the Canadian survey of manufacturing technology and further validated with the responses of the 20 experts .

A list of weights corresponding to each AMT for all 13 industrial sectors was derived for each individual firm, acting as an industry-based frame of reference for both the degree of radicalness and the applicability of AMT's (Lefebvre et. al., 1996).

"Little research has addressed the competitive strategies of small manufacturing firms, particularly their motivations for AMT adoption and implementation" (Mechling *et. al.* 1995). This statement should apply to Uganda's case whose manufacturing firms mainly comprise of small to medium sized enterprises. For researchers, they constitute rather accessible sites for the observation of complex phenomena while remaining distinct enough to preclude simple transfers of empirical results and theoretical knowledge derived from larger firms typical in developed countries.

2.4 Advanced manufacturing technologies

The decision to adopt advanced technologies ultimately rests with the benefits the technology provides and the costs associated with its adoption. In a Canadian 1993 Survey of Innovation and Advanced Technology, advanced technology users identified a wide range of benefits such as improvements in productivity, product quality and working conditions; reductions in production costs associated with such factors as lower labour requirements and inventory, reduced material and energy consumption, increased equipment utilization and reduced product rejection (Baldwin & Da Pont, 1996; Baldwin, Gray, & Johnson, 1996; as cited in Baldwin & Lin, 2002)

Numerous studies have emphasized the potential strategic benefits of flexibility, responsiveness, improved quality and improved productivity through purposeful investment in AMTs (Blois, 1985; De Meyer, Miller, & Ferdows, 1989; Gerwin, 1993; Hall & Nakane, 1990; Hayes & Wheelwright, 1984; Jaikumar, 1986; Jelinek & Goldhar, 1984; J. Meredith, 1987; Tombak, 1990 as cited in Sohal et. al., 2001). Such benefits are increasingly important in the current global manufacturing environment which has been described as ``hypercompetitive'' (D'Aveni, 1994), ``high-velocity'' (Bourgeois & Eisenhardt, 1988; Eisenhardt & Bourgeois, 1988), and characterised by fragmenting markets, shorter product life cycles, and increasing consumer demand for customization (Zammuto & O'Connor, 1992). Thus, AMTs have, and will continue to have, a key strategic role in improving competitiveness by utilising the manufacturing function more effectively in overall business strategy (Hayes & Abernathy, 1980; Hayes & Wheelwright, 1984; Skinner, 1985 as cited in Sohal et. al. 2001).

In 1990, Noori (as cited in Mechling *et. al.* 1995) defined AMT as “a generic term for a group of manufacturing technologies which combine both scope and scale capabilities in a manufacturing environment”. Wiarda (1987), suggested two subgroups of technologies within AMT: the traditional hardware technology consisting of systems, devices and stations (SDS’s) and a second group of technologies, often in software form, which perform integrative and managerial functions referred to as integrative and managerial systems (IMS’s).

In their view Mechling *et.al*. (1995), suggested that both SDS and IMS technologies can be used individually or in combination with other technologies to achieve desired economies of scale and scope. Among South African manufacturers, the most common types of technologies adopted were local area networks, shop-floor data capture, MRP/MRP II, and database management systems. These all represented components of management information systems, and were all focused on intra-company integration. Thus, South African companies' appeared to be investing in technologies that allowed them to integrate all the data associated with the production process - from receipt of raw materials through delivery to customers. These technologies are primarily adopted to improve the efficiency and accuracy of planning, subsequent scheduling and distribution (Sohal *et. al.* 2001). When taken together SDS and IMS constitute AMT (Mechling *et. al.* 1995).

> Exporters who compete in rapidly changing global markets must be able to reduce their product development time and respond quickly to demands for product changeover (Sanchez, 1991). These capabilities depend, to some degree, on the extent to which AMT is linked and integrated. IMS technologies make this linkage and integration possible. Thus, we would expect global competition to drive the adoption of technologies that exploit AMT capabilities. Therefore, exporting firms should have a relatively greater ratio of IMS to SDS technologies than non-exporting firms. We know of no research which has specifically compared AMT adoption patterns in exporting and non-exporting firms (Mechling *et. al.* 1995).

Mechling builds five hypotheses around this statement based on the following two theories: that exporting firms would be expected to adopt a greater variety of AMT than non-exporting firms and; firm size and AMT adoption are also positively related and may impact on the ability of small firms to acquire AMT technology (Mechling *et. al.* 1995), and uses the IMS/SDS ratio to determine the patterns of AMT adoption between exporting and non-exporting firms in the US.

2.5 Modelling Independent Variables

Although Schroder and Sohal (1999), used annual sales as the most relevant measure of firm size, they were quick to note that "the inclusion of firm size and principal ownership variables would be useful additions to the contingency framework" (Schroder & Sohal, 1999). Firm size has been shown to be positively related to adoption of AMT in numerous studies (Gagnon & Toulouse, 1996; Germain, 1996; Germain & Droge, 1995; Kitchell, 1995; Lai & Guynes, 1997; E. Lefebvre & Lefebvre, 1992; Lefebvre et. al., 1996; Thong & Yap, 1995 as cited in Schroder & Sohal, 1999).

In a bid to identify factors inducing AMT adoption in small manufacturing firms, Mechling *et. al.* (1995), categorized firms into exporting and non-exporting but were quick to add that whatever the objectives the adoption of new technology involved uncertainty about achieving the objectives. Gerwin and Tarondeau (1982), discovered that about half of the reasons firms gave for adopting computerized manufacturing systems reflected production-related uncertainty reduction, while Rosenthal (1984), found that in a list of thirteen reasons why companies selected their CAM systems, future add-on capability was the second most popular and modularity was the third (as cited in Gerwin, 1988).

Mamer and McCardle (1987), defined: technological uncertainty as "whether the adoption of the technology will be profitable"; and strategic uncertainty as "how the decisions of competing firms will adversely impact a decision to adopt a new technology" (as cited in Mechling et. al., 1995). Generally, the effects of technological uncertainty can be reduced by research and testing. In contrast, strategic uncertainty is more difficult and problematic to evaluate, frequently relying on speculative efforts to anticipate the decisions of rival firms. Adopting AMT involves both types of uncertainty they conclude.

The account by Gerwin (1988), categorized uncertainty into technical, financial and social. *Technical uncertainty* referring, for example, to the difficulty in determining the precision, reliability and capacity of new processes, and whether still newer technology may soon appear to make the equipment obsolete. *Financial uncertainty* includes whether return on investment should be the major criterion and whether net future returns can be accurately forecasted. *Social uncertainty* is exemplified by questions concerning the nature of the required support system and by the possibility of conflict during implementation.

The foregoing literature discourse on uncertainty leads one to the conclusion that compatibility with existing equipment is a major factor while considering any investment in AMT (Gerwin, 1988; Gerwin & Tarondeau, 1982; Mamer & McCardle, 1987; Mechling et. al., 1995; Rosenthal, 1984).

Recent research shows that, new technology-based companies are confronted with particularly high degrees of uncertainty and ambiguity (Petra & Koenraad, 2006), the set of all feasible business models often not being foreseeable from the outset (Druilhe & Garnsey, 2002, , 2004). Although uncertainty and ambiguity remain present throughout a technology-based company's life, they are most problematic during the early life stages, when the company has only restricted knowledge, experience and resources for dealing with this uncertainty and ambiguity (Bhidé, 2000).

Various studies on innovation and entrepreneurship have alluded to the role of human, technological, financial and networking resources for change, innovation and success (Petra & Koenraad, 2006). Grant (1992), identifies five categories of resources: financial, physical, human, technological and reputation (as cited in Tomás, Espino-Rodríguez, & Padrón-Robaina, 2006). The first two constitute the firm's tangible resources, which are easy to assess and identify, while the others are intangible resources, which are assets with sufficient potential to achieve competitive advantage. According to the resource-based view of the firm, the success or failure of an organization is directly influenced by its resources (Petra & Koenraad, 2006). Organizations can achieve competitive advantage when they have resources that are valuable, rare, inimitable and non-substitutable (Eisenhardt & Martin, 2000); unique, difficult-to-imitate acquired through organizational learning (Dierickx & Cool, 1989); gradually accumulated and shaped organizational capabilities (Dosi, Nelson, & Winter, 2002; as cited in Petra & Koenraad, 2006).

Knoben and Oerlemans (2006), noted that through inter-organizational knowledge sharing, transfer and technology acquisition, firms are assumed to improve their competences, capabilities and resources, which enable them to strengthen their competitive position. Therefore, in an intricate process, different types of proximity also facilitate the performance and survival of organizations.

2.5.1 Employee Skills

Management development programmes are now widely accepted as a means of improving the competitiveness of firms and the economy as a whole. Although management education and training has, in the past, been designed mainly for larger firms, there is a growing awareness of the requirements of small businesses (Fuller-Love, 2006). Almost three-quarters of South African manufacturers perceived a need for training in AMT (71.0 per cent) and in production management (72.1 per cent) (Sohal *et. al.*, 2001). In small firms, the approach is usually to employ someone with the relevant skills already, to save costs, and there is also the preconception that training is for new employees and young people rather than a continuous process of learning (Fuller-Love, 2006). Kitson and Wilkinson (1998), found that older firms were more likely to provide training than recently established ones and that manufacturing firms were more likely to provide training than were service firms (as cited in Fuller-Love, 2006). Part of the problem for small firms Fuller-Love (2006) notes, is that “entrepreneurs, by their nature, are less likely to have formal educational qualifications and have started their own small business as a means of improving their earning potential”.

Both Rodrik (1992) and Lall (1990), suggest that effects of liberalization may take some time to materialize “trade reforms may need to be complemented by increased investment in skills and training and greater in-house technological efforts” (as cited in Katrak, 2000). Barber, Metcalfe and Porteous *(1989)*, found that barriers to growth in a small firm are often related to learning and Perren (1999) noted that the motivation for some entrepreneurs was to achieve a certain level of income rather than grow the business (as cited in Fuller-Love, 2006).

Fast-growing and innovative firms spend more on training than do older, slow-growing and non-innovative firms and the use of external training providers was lower for stagnant and declining firms (Kitson & Wilkinson, 1998). It is clear that there is some relationship between growth and training, although it is difficult to determine which comes first. Small firms that are growing rapidly may need to invest more in training in order to carry on expanding, and firms which invest in training may be more open to new ideas and opportunities and are therefore more likely to grow (Fuller-Love, 2006).

Research into the educational background of entrepreneurs in Europe found that less than one-third had a university degree (Roure, 1997, as cited in Fuller-Love, 2006). Gold (1980), found an absence of computer aided manufacturing expertise among senior officials of American companies which he claimed was a barrier to acceptance of AMT's (as cited in Gerwin, 1988).

In their study focusing on the role and contribution of intangible assets Lefebvre et al. (1996), developed a model based on three sets of independent variables. The first set of independent variables, corresponding to the acquired technical capabilities of the different categories of employees, was measured as the actual percentage of employees within each category who were using computer-based technologies on a daily basis in their work activities. 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 (CNC 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 AMT adoption rate. As a consequence, the extent of use of computer-based applications was assessed for all types of employees (Lefebvre et al., 1996).

The results showed that;

> the most important users of computer-based technologies are clerical and secretarial workers, who are also usually the first groups involved in the use of information technologies. In SME's, these two groups of employees are heavily involved with computer-based applications such as basic financial accounting or word processing and, in most firms, cost accounting, inventory control or billing, and even job-order costing, which are applications closely related to production operations. The technical capabilities of these employees contribute to a more "technical organizational climate" which, directly or indirectly, influences technology strategy. Furthermore, in many cases, a spiral effect seemed to be associated with the new capabilities brought about by the new manufacturing technologies: for example, the adoption of AMT's led to an increasing number of customized products

> which, in turn, required more sophisticated systems to ensure adequate control and follow-up of all manufacturing activities *(Lefebvre et al., 1996).*

The technical capabilities of blue-collar workers were found to be related significantly and positively to further AMT adoption. This could correspond to "experiential learning-by-doing or first order learning." Infact it, could reasonably be assumed that the smaller manufacturing firms relied mostly on this form of learning. Indeed, skilled blue-collar workers already experienced with the functioning and operation of AMT's are a rare commodity; acquiring and retaining such skilled workers constitutes a formidable challenge for smaller manufacturing firms. In most cases, SME:'s must invest heavily in on-the-job learning whereby blue-collar workers acquire skills and capabilities with technology through on-going exposure to and use of the more sophisticated machinery. Yet this does not always translate into longer-term benefits for smaller firms since a significant percentage of these skilled blue-collar workers prefer to leave for the better paying jobs and improved working conditions offered by larger firms *(Lefebvre et al., 1996).*

Lefebvre et. al. (1996), further conclude that;

> The effect of white-collar workers was significant though far less important. It is possible that white-collar workers are experienced with computer-based information technologies but have little knowledge of manufacturing technologies. It may well be the case that the integration of information and production technologies is not yet a reality in smaller firms.

2.5.2 Internal and External Influences

Organizations can be viewed as dynamic systems of adaptation and change – two terms that are often used interchangeably – that contain multiple parts that interact with one another and the environment (Morel & Ramanujan, 1999). Change or adaptation is often regarded as an organization’s response to changes in external factors, threats and opportunities (Kraatz, 1998). Other research streams focus more on internal pressures for organizational change. A more inclusive view on change suggests that both external and internal pressures for change are relevant (Morel & Ramanujan, 1999). Existing views on adaptation and their definition of ‘change’ differ with respect to (1) whether the pressures for change reside within the organization or within its environment, (2) timing and (3) the radical nature of change (Petra & Koenraad, 2006). Examples are the distinction between market pull and technology push, as an internal driver for innovation, as well as the shift in focus from product solutions to customer solutions as an indication of external pressures for change (Burgelman, Maidique, & Wheelwright, 2001; Christensen, 1997; Christensen & Raynor, 2003; Henderson & Clark, 1990; Von Hippel, 1988 as cited in Petra & Koenraad, 2006).

In the their study focusing on the role and contribution of intangible assets on one major strategic decision-making process, Lefebvre *et al.* (1996), directed attention to process issues, namely the political (influences) and informational (motivations) dimensions of the decision-making process taking into account the level of existing technical skills. Rosenthal (1984) surveyed users and vendors of computer aided manufacturing processes. Seventy six percent of the vendor personnel said inability to quantify returns was either significant or very significant in the decisions of potential users not to purchase their technology (as cited in Gerwin, 1988).

In Gerwin (1981), the person generally acknowledged as the Flexible Manufacturing System's (FMS) champion, the head of manufacturing engineering, took the lead in selling the FMS to divisional management. His solid commitment was characterized in the interviews as having a positive impact on the decision to accept his proposals (Gerwin, 1988). Pitt and Kannemeyer (2000), investigated the effect of the entrepreneur's personality traits (intolerance of ambiguity, locus of control and risk taking propensity) in new technology based ventures on the degree to which marketing strategy has changed (as cited in Petra & Koenraad, 2006).

Scott *et al.* (1989), encountered problems when attempting to find out what owner-managers did in small firms and were given general responses such as "I run the firm" (1989). The business is seen as an extension of their self-image and also as a personal possession to do with what they want: "It is important to realise that for many owner-managers the business is essentially an extension of their own ego" (Scott et. al., 1989). This may create problems when it comes to expanding the business and developing management systems. To change their way of managing the business can be very difficult. Often, the owner-manager has a lot at stake in the way of personal guarantees, and the family home may be used as security for bank loans. This makes it very difficult to bring in professional management systems, which may or may not work. In other management disciplines, authors have highlighted that the management activities of small firms are substantially different from those of large firms (Eisen, Mulraney, & Sohal, 1992; Kohse, 1994; Robinson & Pearce, 1984; as cited in Schroder & Sohal, 1999).

Schroder & Sohal (1999), noted that, Australasian owned companies had more influence from top management in the generation of the AMT ideas as compared to foreign owned companies. Conversely, foreign owned companies had more involvement from senior management. There was a significant difference between type of ownership in terms of top and senior management involvement in the generation of the AMT investment idea.

Lefebvre *et. al.* (1996), went ahead to identify a second set of independent variables as those pertaining to the influences of internal and external proponents and measured each of them on a five-point Likert scale. Six different groups or individuals within organizations were identified. The CEO, marketing and engineering and production formed the internal influences while consultants, suppliers of technologies and customers comprised the external proponents.

The strongest single influence was that of the CEO while the internal functional groups with the exception of the marketing groups, appeared in general to be more influential than external groups Lefebvre et. al. (1996). According to Fuller-Love (2006), management in a small firm is closely linked to the skills and characteristics of the owner-manager. The entrepreneur's educational and family background was likely to have an impact on the management style of a small-business owner-manager. Storey (1986), emphasized the importance of realizing that small firms are not 'scaled down' versions of large firms. In large firms, decisions are made by the chief executive and carried out by others, and the role of the chief executive is to monitor whether they are carried out effectively. In a small company, the owner-manager is in direct contact with the employees and usually has a greater awareness of what is going on, and often does not see the need for procedures to monitor performance (Fuller-Love, 2006).

Sohal et. al.(2001) showed that the ideas for investing in AMT were overwhelmingly generated by personnel from production (51.4 per cent) and engineering (16.7 per cent) functions. R&D and production engineering were also responsible for generating AMT investment ideas in some organisations (9.7 per cent and 6.9 per cent, respectively). There was clear evidence of crossfunctional involvement in AMT idea generation. In terms of management involvement, top and senior management levels were responsible for generating 99 per cent of the AMT investment ideas. This demonstrates a commitment from senior management to AMT, noted in many studies as critical to the success of ongoing technological process innovation (Farhooman, Kira, & Williams, 1990; Voss, 1988; Vrakking, 1989 as cited in Sohal et. al. , 2001).

Clearly the generation of AMT investment ideas is top-down, with both top and senior management and technical levels providing the main drive in the generation of investment ideas. There is a significant relationship between the size of the company and whether or not production engineering generated the AMT investment idea. Production engineering is much less likely to generate the investment idea in medium-size companies. Smaller companies are more likely to have top management involvement in AMT investment idea generation. However, larger companies are more likely to have involvement from senior management in AMT investment idea generation, a level lower than top management. There is a significant relationship between the size of the firm and whether or not middle level technical staffs' were involved in the idea generation. Larger companies are more likely to have the AMT ideas generated by middle level technical staff (Schroder & Sohal, 1999).

Government policies and interventions undoubtedly are vital external proponents in the implementation or investment in AMT's. These include among others tax breaks, favourable financing, protection from competition and energy availability. Fuller-Love (2006), for example noted that "in the U.K. Government initiatives designed to encourage start-ups and to boost the growth of small firms emphasized the importance of management development". Mechling et. al. (1995), cites literature that identifies external influences that induce AMT adoption these include: tax incentives (Sanchez, 1991); environmental, safety or health concerns (Jimenez, Martinez, Navarro, Polo, & Tomas, 1992; Sanchez, 1991); whereas Sung and Carlsson (2003), in their study that analyzed the evolution process and performance of Korea's technological system for CNC machine tools as a catching-up case noted that the Korean government played a 'macro-entrepreneurial' role in the moulding of the technological system by giving legitimacy to the system, mobilizing a nation-specific industrial organization of 'Chaebol' system and enhancing the academia-industry-research institutional links. The study also shows that despite this, the length of the 'learning period' was substantial even in a catching-up case. It noted that the country's revealed comparative advantage (RCA) index of CNC lathes had rapidly increased over the past two decades and recognized that many factors contributed to this industrial development. The study therefore takes a systems view of innovation and analyzes the development of the Korean CNC machine tool industry using the technological systems approach. The approach, it is stated, finds its usefulness in that it not only focuses on a technology/product or technologies/products rather than industrial clusters, nations or regions but also emphasizes the fact that systems evolve over time. Petra & Koenraad (2006), find it necessary to check for interaction effects between technological, financial, human and networking resources, both initially present and accumulated over time and if firms' resources turn out to enable adaptation, then is an organizational capability and not just a personal skill of the entrepreneur.

Policies for promoting the machine tool industry in Japan were referred to as "the industrial policy to nurture strategic industries (Tsuji, 2003). It was practiced by means of tariff and non-tariff barriers which regulate foreign competitors in the Japanese market. It also contained other policy options such as tax incentive schemes including tax credit for purchasing equipment and special allowances for depreciation as well as provision of public funds as direct subsidies or with a low interest rate through, for example, the Fiscal Investment and Loan Program (FILP). In the context of industrial policy for the machine tool industry, this system provided the financial basis for the Promotion of Mechanical Industry Act, enacted in 1956, which was revised three times and in effect for 15 years. The act aimed to promote the modernisation of equipment of the general machinery industry. Since general machinery is one of the major users of machine tools, this act was effective in increasing the demand for machine tools.

While earlier policies helped some countries to build a broad industrial base, they also led to considerable technological backwardness through the continued use of old technologies and machines and limited attention to cost-saving processes and/or improving product quality *(Ahluwalia, 1991; as cited in Katrak, 2000)*. Katrak (2000), therefore concludes;

> Developing countries hope that the removal (or reduction) of restrictions on imports of machines and technological know-how will allow their enterprises to introduce newer and better quality machines, machine tools and technological know-how and that the move to pro-competition policies will generate the pressures and incentives for these changes.

Although in terms of tariffs, the Japanese industrial policy for the machine tool industry did not aim at protecting the domestic industry in terms of finance, the industrial policy was quite effective for developing the machine tool industry (Tsuji, 2003).

In Uganda government is implementing a Medium Term Competitive Strategy (MTCS) for the private sector.

> The MTCS was approved by Cabinet in August 2000 and formally adopted as a Government and five-year reform agenda for Private Sector Development. To kick start its implementation, Government constituted Technical Working Groups (TWGs) drawing representatives from Government, Donors and the Private Sector. The main task of the TWGs is to come up with detailed actions and implementation, monitoring and evaluation mechanisms for the MTCS. To foster its smooth implementation, requires effective coordination amongst a number of key agencies within the Government machinery and in the private sector. Key to this process was collaboration between the Ministries of Finance, Planning and Economic Development, Tourism, Trade and Industry and of Justice and Constitutional Affairs (MFPED, 2001).

Key areas this strategy addresses among others include:

- Improving access by small and medium sized business to machinery and equipment through asset leasing
- Accessing foreign markets
- Institutional support for Private sector development
- Improving the regulatory environment for business
- Commercial justice reform

Through the Medium Term Competitive Strategy (MTCS), the Uganda Government intends to put in place a regulatory environment that encourages asset leasing as a valuable development tool, and which supports better access by small to medium sized businesses to the use of leasing for financing capital investment (MFPED, 2001).

The Japanese way of developing technology is in remarkable contrast to that of other East Asian economies, where growth has been driven by the FDI of Western firms. By making use of FDI, those economies acquired new technology. This type of industrial development is called “leapfrogging,” which indicates that those countries bypassed the acquisition of basic technology or R&D (Barro & Sala-I-Martin, 1995; Hobday, 1995; Soete, 1985; as cited in Tsuji, 2003).

According to Tsuji (2003), from the viewpoint of acquisition of high technology, FDI is not necessarily the best way towards becoming independent of foreign technology. As is often pointed out, multinational companies do not necessarily transfer the technology they possess.

2.5.3 Strategic Motivations

Dynamic capabilities are about continuously integrating, building and reconfiguring internal and external competences (i.e. organizational routines and processes that are typically viable across multiple product lines, individual business units within an organization and even outside the organization) to address changing environments (Burgelman et. al., 2001; Helfat & Peteraf, 2003; Helfat & Raubitschek, 2000; Teece, Pisano, & Shuen, 1997 as cited in Petra & Koenraad, 2006).

The benefits of technology use are far ranging—from increasing productivity, to improving flexibility, to producing higher quality products, to reducing production costs (Beaumont & Schroder, 1997; Rischel & Burns, 1997; Small, 1998 as cited in Baldwin & Lin, 2002). These all constitute strategic motivations relevant to a firm’s adoption of AMT’s. Previous studies have found significant differences between Australasian owned and foreign owned firms in Australia with regard to the importance of ``improved quality", ``obtaining competitive advantage", ``increased throughput", ``increased sales", ``improved management attitude", and ``improved integration of information systems across functions" as anticipated benefits. In all cases Australasian owned companies placed more importance on these benefits (Schroder & Sohal, 1999).

Sohal *et. al.* list twenty-six potential benefits of AMT in a questionnaire where respondents were asked to rate each one on a five-point Likert scale where 1 = ``great importance" and 5 = ``no importance". The first six benefits identified as most important were; obtaining competitive advantage, increased throughput, improved quality, reduced costs, better management control, and increased flexibility. Competitive advantage came through as a critical aspect. However, it is coupled with anticipated benefits which may best be described as operational, while longer-term strategic benefits are not highly rated. Multivariate analysis of variance was used to test for differences in the perceived benefits from AMT across different types of AMT, company size, and type of manufacturing system. The overall multivariate results showed that there were no overall differences in the perceived benefits from AMT across different types of AMT, company size, and type of manufacturing system (Sohal et. al., 2001). In the end the decision on whether or not to acquire advanced technologies depended on the benefits that the technology provides and the costs associated with its adoption (Baldwin & Lin, 2002).

In Lefebvre *et. al (1996),* the third set of independent variables represented the *strategic motivations* for further AMT adoption and corresponded to the operational measures proposed by Miller and Roth (1988), to assess manufacturing success in terms of the quality of products, flexibility of the manufacturing process and delivery, whereas other measures related to cost reduction motivations were derived mainly from the work of Pimrose and Leonard (1985). The resulting seven variables captured the main strategic motivations in SME's and the construct reliability for these perceptual variables proved to be quite satisfactory, with Cronbach alpha coefficients ranging from 0.68 to 0.92 (Lefebvre *et. al.* 1996). The results showed that cost reductions (labour costs and cost of finished products), although quite important, did not appear to be of primary concern.

Meredith (1987a), indicated that, smaller manufacturing firms rarely compete on cost leadership alone but, rather, tend to exploit other competitive advantages such as greater customization and the higher quality of the products and services offered (as cited in Lefebvre *et al.* 1996).

Improvements in productivity occur when the same output can be produced with fewer inputs. This leads to a reduction in production costs. Production costs can also be reduced when lower cost inputs can be substituted for higher cost inputs, when lower skilled labour can be substituted for higher skilled labour. Flexibility is a benefit when product line diversity can be extended by new technologies. Product quality improvements result from lower scrappage rates or from more reliable products (Baldwin & Lin, 2002).

Mechling (1995), also cites literature that identifies a variety of technical and strategic factors that induce AMT adoption: reduced product development time (Tomback & De Meyer, 1988); labour costs savings (Gaimon, 1989; Sanchez, 1991); material costs savings (Sanchez, 1991); a need to remain competitive (Fine & Li, 1988; Tomback & De Meyer, 1988); financing availability (Sanchez, 1991); a need for product change flexibility (Gaimon, 1989; Jaikumar, 1986); increased profitability or plant performance (Sanchez, 1991); and customer requirements (Lei & Goldhar, 1991).

Overall productivity improvements can be achieved through a variety of means, e.g. a reduction in labour usage, raw material or energy consumption, and better equipment utilization. To various degrees, advanced technology users identify benefits in all of these areas. But the dominant category here is a reduction in labour requirements. Labour costs are, however, not reduced by substituting unskilled for skilled labour. In general, a larger percentage of firms indicated that skill levels increased rather than decreased (Baldwin & Lin, 2002).

However Hickson, Butler, Cray, Mallory, and Wilson (1986), is quick to note that a decision which is considered strategic in one industry may be less strategic or not strategic at all in another. For example, a decision to introduce a new product (e.g. a car) in the automotive industry can be a strategic one; while the decision to introduce a new product (e.g. a children's toy) in a factory which produces hundreds of new toys every year may not be a strategic one (as cited in Elbanna, 2006).

Proximity in general is often seen as an important pre-condition for knowledge sharing, knowledge transfer and technology acquisition processes (Gertler, 1995; as cited in Knoben & Oerlemans, 2006), which are often seen as the primary goals of Inter- organization collaboration (Hagedoorn & Schakenraad, 1994). With regard to technology transfer arrangements as an option for the Ugandan industry, Bennet, Vaidya, & Zhao (1999) referred to the technology supplier as the "owner" (of the technology) and the recipient as the "acquirer" noted that;

> For a technology transfer arrangement to be acceptable to both parties it is necessary for their objectives to be substantially compatible… Some objectives are compatible in the short run (e.g. increased sales in the local market). Some objectives may lead to compatibility in the future (e.g. the owners' objective of developing a lower cost production base and supply chain and the acquirers' objective of gaining access to the world market). Some objectives may appear to be divergent. For example, the owner's "cost reduction" objective does not appear to be compatible with the acquirer's "development of technological capability". However, collaboration with a lower cost and technologically capable partner could be part of an owner's global strategy (Bennet et. al., 1999).

Adoption of AMT's has long been considered a key factor in the competitiveness of manufacturing firms and one which requires large financial and non-financial resources and which has tremendous organizational impacts. In fact, in some cases, delaying adoption can p1ace the very survival of firms into question. For these reasons, the decision to adopt AMT's is considered to be a major strategic decision (Naik & Chakravarty, 1992 as cited in Lefebvre et. al., 1996).

In the Background to the Budget 2001-2002, the Uganda government attempts to address the above issues by pragmatically pursuing regional integration arrangements in COMESA and EAC (MFPED, 2001). Among others benefits are expected in areas such as:

- Opening of markets and investment opportunities within the region;
- Enhancing efficiency in production through increased specialisation in accordance with comparative advantage;
- Increased production levels due to better exploitation of economies of scale made possible by the increased size of the market;

This may appear as a solution because the establishment of production facilities is limited in part by the increasing scales that emerged with industrialization. With respect to developing countries, the small size of their domestic market reinforces this argument. In the same light Alcorta & Ludovico (2001), point out exports could provide a way out of the scale problem but immediately caution that a minimum of efficiency is often necessary prior to entering foreign markets. This argument is strengthened by supporters of new technologies who claim that:

> "Microelectronics-based forms of flexible automation (FA) and design are leading to fundamental changes in economies of scale. The increasing replacement of old mass production, single purpose, fixed equipment by newly computer-controlled FA is said to be resulting in reduced optimal scales of output while, at the same time, raising the flexibility of production units to switch to the manufacture of a wider variety of scope of goods and reap economies of scope. One important consequence of falling optimal plant and firm scales, with growing economies of scope, is that entry by small-scale flexible and efficient producers becomes possible" (Acs & Audretsch, 1998; as cited in Alcorta & Ludovico, 2001).

Outsourcing can be considered another strategic motivation. Outsourcing has been defined as "The act of trusting in external capabilities and skills for the manufacture of determined production components and other activities that have added value (often capital intensive)". This is clearly an opportunity that can be taken advantage of by developing countries (Lei & Hitt, 1995; as cited in Tomás et. al., 2006). Outsourcing influences the resources allocated to business units as well as the level of vertical specialization of the firm's activities, both of which are corporate strategy (Quélin & Duhamel, 2003). In that respect, strategic outsourcing modifies the firm's boundaries and so is also considered a business strategy (Insinga & Werle, 2000; as cited in Tomás et. al., 2006).

On the other hand in the context of outsourcing, by analyzing the relationship between strategy and the environment the strategic approach examines how a function or operation affects the firm's competitive advantage, which, in turn, can affect its organizational performance (Tomás *et. al.* 2006).

Process issues remained an understudied area of research on strategic decision-making although renewed interest in the subject was observable (Rajagopalan, Rosheed, & Datta., 1993 as cited in Lefebvre et. al.). However, generally dynamic capabilities will govern the rate of change of ordinary capabilities (Collins, 1994; Winter, 2003). Examples are capabilities that change the product, the production process, the scale or the customers. Product development, strategic decision-making and alliancing have been put forward as concrete examples of dynamic capabilities (Eisenhardt & Martin, 2000; Teece et. al., 1997 as cited in Petra & Koenraad, 2006).

2.5.4 Impediments to AMT Adoption

In a recent study of South African manufacturers, 12 potential risks and difficulties were listed. The most interesting aspects are that most of the difficulties were not highly rated except for, disruptions during implementation and failure to achieve financial targets. Interestingly opposition by workforce was rated least important. There were no differences in the perceived risks and difficulties across the type of manufacturing system and the three types of AMT (computer hardware, software and plant and equipment). However, there were differences in perceived risks and difficulties across small, medium and large size companies ($F = 2.339$, $df = 11$, $p = 0.034$). Differences were also noted between company size categories in terms of the failure to achieve financial targets ($F = 4.212$, $df = 1$, $p = 0.022$) and production management skill deficiencies ($F = 7.010$, $df = 1$, $p = 0.003$). In both cases large companies rated these difficulties less important than medium and small companies. The results suggest that larger companies have greater slack resources to absorb some of the risk associated with AMT investment, and that larger companies have a higher level of production management skill (Sohal et. al., 2001).

`The impediments that were investigated by Baldwin and Lin (2002), can be divided into five groups. The first includes a set of general cost-related problems associated with advanced technology adoption, including the cost of capital, the cost of technology acquisition, the cost of related equipment acquisition, the cost of related software development, and increased maintenance expenses. Four other areas were also identified—impediments that arise from government policy (institutional-related problems), from labour market imperfections, from internal organization problems and from imperfections in the market for information. Each of these also increases the costs of adopting advanced technology—but the causes are somewhat more narrowly focused than the general cost-related items that are included in the first category.

Past studies have shown that Government policies and interventions in relation to tax breaks, favourable financing, protection from competition and energy availability among others, are useful in overcoming impediments to AMT penetration. Mechling et. al. (1995), cites literature that identifies external influences that induce AMT adoption these include: tax incentives (Sanchez, 1991); environmental, safety or health concerns (Jimenez et. al., 1992; Sanchez, 1991). Other impediments not related to government interventions include inability to quantify returns (Rosenthal, 1984).

In a Canadian 1993 Survey of Innovation and Advanced Technology, advanced technology users reported a host of costs associated with technology acquisition, e.g. education and training, time and cost to develop required software, and increased maintenance expenses. In addition to these costs, all firms reported a series of other impediments to their technology adoption. These include institution-related problems associated with tax regimes, and government regulations and standards; labour-related problems such as shortage of skills, training difficulties, and labour contracts; organizational or strategic problems associated with difficulties in introducing important changes to the organization, management attitude, and worker resistance; information-related problems such as lack of scientific and technical information, technological services, and technical support from vendors (Baldwin & Da Pont, 1996; Baldwin et. al., 1996 as cited in Baldwin & Lin 2002). Similar lists of impediments have been used to investigate barriers to innovation (Arundel, 1997). The decision to adopt advanced technologies ultimately rests on the benefits that the technology provides and the costs associated with its adoption. The latter depend upon the impediments that firms face (Baldwin & Lin, 2002).

Among the five broad groups of impediments, general cost-related problems are the most important and most frequently reported by firms. This is followed in order by labour-related problems stemming from skill shortages, organization-related problems (management/worker attitude), institution-related problems (associated with the R&D investment tax credit, capital cost allowance and government regulations) and information-related problems (such as lack of scientific and technical information, lack of technological services and lack of technical support from vendors) (Baldwin & Lin, 2002).

An argument is put forward by Schroder & Sohal that, larger firms have greater slack resources; therefore they invest in a greater volume and range of AMT, and thus capture more of the integrative benefits of AMT and improve overall performance. Additionally, larger firms are likely to have more supportive infrastructure and resources to undertake formal planning and evaluation for AMT. An increase in these variables will have a positive moderating effect on the relationship between adoption of AMT and performance, and thus improve overall performance (1999). Overall, the findings suggest that larger companies are making more AMT investments and larger AMT investments (Schroder & Sohal, 1999).

However, Baldwin and Lin (2002), argue that if impediments were the primary deterrents to technology use and innovation, it might be expected that non-users and non-innovators would report higher impediments. This was not the case. With rare exceptions, the percentage of users reporting impediments is markedly and consistently higher than among non-users; it is also more frequent among innovators than non-innovators . This may be attributed to the fact that non-users have never had the opportunity to experience the impediments to acquiring AMTs.

2.5.5 Flexibility Strategies

In a company studied by Gerwin (1988), an objective of minimizing disaster rather than maximizing profits in selecting a flexible manufacturing system over a modified transfer line to that of manufacturing a new product line was explicitly followed. Thus if the new product line turned out to be a commercial failure, the FMS would be flexible enough to machine a redesigned line or possibly be put to other uses without much additional cost.

Alcorta and Ludovico (2001), find out that the replacement of old, mainly conventional, machine tools and transfer lines by new computer-numerically-controlled machine tools and related flexible automation (FA) has resulted in lower economical batch sizes and the manufacturing of growing variety, making it possible to reap economies of scope. They go on further to note that scale and scope economies at product level have reinforced scale economies at plant level, resulting in higher levels of optimal output.

(Both Abegglen, Stalk, & Kaisha, 1985; Stalk & Hout, 1990 as cited in Mechling et. al. 1995), suggest that time-based competition is the most advantageous strategy in today’s market place.

> Product diversity is increasing, product life cycles are decreasing, and cost patterns are shifting. Global and domestic manufacturers must now include flexibility and time-based

> technologies in their manufacturing capability. Rather than traditional economies of scale, new strategies must facilitate flexibility, reduce design cycle time, reduce time to market, and reduce order cycle time. For manufacturing to be the new competitive weapon, management must respond with new and agile manufacturing strategies for both the domestic and global environment. The adoption of AMT is one way to respond to this growing need for flexibility and time-based capabilities in manufacturing.

2.5.6 Risk Taking and Discovery

The changes of our society from being agriculture-centred to becoming manufacturing-centred and then knowledge-centred have created fertile ground for those with ingenious solutions to a wide range of problems (*Enhancing inventiveness for quality of life, competitiveness and sustainability*, 2004).

Innovation in manufacturing processes is traditionally considered to have as its objective increased flexibility, decreased costs or improved quality (Gerwin, 1988). According to (*Enhancing inventiveness for quality of life, competitiveness and sustainability*, 2004):

> Many inventors in poorer countries are compelled to become social entrepreneurs. Their goals are not just to develop innovative products; they also carry out an important social function in helping to see their products adopted by communities, creating livelihoods in the process. This produces a greater set of hurdles for inventors in these contexts.
>
> Banks and venture funds do not like lending to social entrepreneurs because of concern that they lack business experience and also because social entrepreneurs tend to be less interested in protecting their inventions; some encourage replication if it means a product will reach more people. Such practices, however, prevent social entrepreneurs from raising the appropriate level of finance needed for mass production and marketing.

A positive link has been established between training and innovation and growth, as training was provided by 60% of innovating firms but only 41% of non-innovators, and 72% and 68% of medium and fast-growing firms respectively, compared with 46% of stagnant and declining firms (Kitson & Wilkinson, 1998 as cited in Fuller-Love, 2006).

It is crucial on both theoretical and practical grounds to measure the degree of radicalness of AMT penetration since it is known to be “an essential attribute of innovations and since AMT adoption is indeed sector-specific” (Lefebvre et. al., 1996)

Baldwin and Lin (2002), explore the innovation activity of the firm owning the plant—incidence of innovation, existence of research and development units, and the characteristics of the firm’s competitive environment. Their study provided measures of impediments to technology use and measures of the technological and innovative activity of establishments and their owning enterprises . As highlighted earlier non-users and non-innovators reported lower impediments to AMT adoption.

> A learning-by-doing model of technology adoption can explain this phenomenon. Firms have to assess the benefits of implementing technological changes. Firms that are innovative reap substantial benefits ... In order to reap those benefits, they have to incur the higher costs of new equipment and of research and development facilities. Other research has shown that there are many types of costs that are higher for technology users and innovators. For one, more technologically advanced firms find that their skill requirements increase after new technologies are introduced (Baldwin & Da Pont, 1996; Baldwin et. al., 1996). Training is more likely in firms that are high-tech users or innovators (Baldwin & Johnson, 1999). Moreover, firms that are innovators are more likely to be developing greater competencies in other areas besides just human resources. More innovative firms (especially those that introduced new products and new processes) develop greater competencies in a wide range of areas. They gain more from their high-risk innovation strategy, but they risk more and they incur higher costs because they have to master a wider range of competencies (Baldwin, 1999; Baldwin & Johnson, 1999 ; as cited in Baldwin & Lin, 2002).

(*Enhancing inventiveness for quality of life, competitiveness and sustainability*, 2004) conclude that:

> There are only limited incentives in the developed world for inventing products or processes for the developing world, because the final rewards of such inventing are typically small. Effective sustainable development will require new mechanisms for innovation that encourage invention as well as manufacturing and marketing systems, which are specifically designed to create sustainable solutions.

2.5.7 Collaboration with other firms

Knoben and Oerlemans (2006), distinguished three dimensions of proximity relevant in inter-organizational collaboration: geographical proximity, organizational proximity and technological proximity.

When the proximity concept is used, what is often actually meant is geographical proximity. However, other forms of proximity, such as institutional proximity (Kirat & Lung, 1999), organizational proximity (Meisters & Werker, 2004), cultural proximity (Gill & Butler, 2003), social proximity (Bradshaw, 2001) and technological proximity (Greunz, 2003) are used as well. Even though all of these dimensions of the concept of proximity refer to ‘being close to something measured on a certain dimension’, they are certainly not identical. Many of the dimensions of the proximity concept are, however, defined and measured in many different (sometimes even contradictory) ways, show large amounts of overlap, and often are under- or over-specified (Knoben & Oerlemans, 2006).

Worth noting, earlier Eisenhardt and Martin (2000) and Teece *et al. (1997)*, had also mentioned alliancing as one example of dynamic capabilities (as cited in Knoben & Oerlemans, 2006).

The phenomenon of outsourcing is becoming increasingly widespread among organizations and is now one of the strategic decisions that attract the greatest interest from professionals and organizational scholars (Tomás *et. al.* 2006). Tsuji (2003), determined the catching up of the Japanese machine tool industry with that of the West by studying the decline in the number of technology cooperation agreements. This cooperation was in the form of technology-related contracts and agreements and was characterized by the acquisition of patents, gaining know-how as well as the purchase of machine tools to serve as samples.

Petra and Koenraad (2006), studied the effect of resources on adaptation in newly technological based ventures and predicted an interaction effect between technological, financial, human and networking resources, both initially present and accumulated over time. For example, the absorptive capacity of an organization – which is related to an organization's pre-existing knowledge structure (Cohen & Levinthal, 1990) – will influence its ability to use new information (Burgelman et al., 2001; Roberts, 1991), such as information gathered through networking (as cited in Petra & Koenraad, 2006).

In their study (Tomás *et. al.* 2006) go ahead to list 15 additional definitions by different Authors of the term outsourcing and classify them into three types. Based on these definitions, an integrated definition that encompasses all the aspects and provides a frame of reference for their work is drawn:

> Outsourcing is a strategic decision that entails the external contracting of determined non-strategic activities or business processes necessary for the manufacture of goods or the provision of services by means of agreements or contracts with higher capability firms to undertake those activities or business processes, with the aim of improving competitive advantage (Tomás et. al. 2006).

2.5.8 Machine shop capabilities

Carlsson and Stankiewicz (1991), defined the technological system as 'network(s) of agents interacting in a specific technology area under a particular institutional infrastructure to generate, diffuse and utilize technology' (as cited in Sung & Carlsson, 2003). In Sung and Carlsson (2003), three levels were identified to which the approach could be applied: to a technology in the sense of a knowledge field, to a product or artifact, or finally to a set of related products and artifacts aimed at satisfying a particular function, such as health care or transport. The study took a product, CNC machine tools, as the initial seed from which the system is defined.

As for the machine tool industry in Japan, Tsuji (2003), focus on the Japanese way of technological development and management:

The Japanese manufacturing industry more or less began with an imitative process called "reverse engineering," that is, making a "dead-copy" and gradually absorbed advanced technology. Along with this process, two types of technology—Western and indigenous—the latter indicating accumulated skills and traditional craftsmanship, were assimilated into "Japanese technology".

Japan has succeeded in world markets by focusing its attention on the importance of superior manufacturing systems and techniques. Thus, manufacturing may be the "sleeping giant" within firms and prove to be a formidable competitive weapon in the global marketplace. One way that firms can achieve a competitive advantage in manufacturing is through the employment of AMT's (Mechling et. al. 1995). Studies on industry evolution and evolutionary economics further suggest the need for continuous change over extended periods of time. In continuously changing markets, dynamic capabilities – as opposed to ad hoc fire fighting – are often regarded as a main source of sustained competitive advantage (Petra & Koenraad, 2006).

2.6 Conclusion

The new role of manufacturing demands that the market place of the twenty-first century evolves into one of merging national markets, fragmented consumer markets, and rapidly changing product technologies. These changes are driving firms to compete, simultaneously, along several different dimensions: design, manufacturing, distribution, communication, sales and others. Although manufacturing has not been utilized as a competitive weapon historically, the market place of the twenty first century will demand that manufacturing assume a crucial role in the new competitive arena (Mechling *et. al.* 1995).

The foregoing literature provides alternatives for the optimal modelling of AMT development that measure its penetration based on a number of scales determined by technological and innovative activity among others. A dichotomous variable for usage or non usage that does not take into account the intensity as well as a continuous variable reflecting total number of AMT's in use that solves the problem of intensity of technology use was presented by Baldwin and Lin (2002). A similar variable to the latter is provided by Mechling *et. al.* (1995), that measured the breadth of adoption. Baldwin and Lin (2002), measured both intensity of use and non-linear impact by using a set of binary variables capturing different intensities. Mechling *et. al.* (1995), measured patterns of AMT adoption by categorising intensity or breadth into IMS and SDS the obtaining ratio is then used as a dependant variable that measured the degree to which firms' were integrating their hardware devices. Lefebrve *et. al.* (1996), used weights acting as an industry-based frame of reference for both the degree of radicalness and the applicability of AMT's. The dependent variable corresponded to a ratio of two weighted sums: the weighted sum of the AMT's being considered for adoption divided by the weighted sum of all potential AMT's.

The literature though diverse is unanimous about the categories of determinants for penetration and adoption of AMT's. Many authors contend that organizations can be viewed as dynamic systems (Burgelman et. al., 2001; Eisenhardt & Martin, 2000; Helfat & Peteraf, 2003; Helfat & Raubitschek, 2000; Morel & Ramanujan, 1999; Petra & Koenraad, 2006; Teece et. al., 1997).

Generally benefits of AMT technology are broad ranging from increasing productivity, to improving flexibility, to producing higher quality products, to reducing production costs (Baldwin & Lin, 2002; Beaumont & Schroder, 1997; Rischel & Burns, 1997; Small, 1998). Obtaining competitive advantage, increased throughput, improved quality, reduced costs, better management control, and increased flexibility are benefits suggested by Sohal *et. al.* (2001). Other citations include reduced product development time (Tomback & De Meyer, 1988); labour costs savings (Gaimon, 1989; Sanchez, 1991); material costs savings (Sanchez, 1991); a need to remain competitive (Fine & Li, 1988; Tomback & De Meyer, 1988); financing availability (Sanchez, 1991); a need for product change flexibility (Gaimon, 1989; Jaikumar, 1986); increased profitability or plant performance (Sanchez, 1991); and customer requirements (Lei & Goldhar, 1991).

Impediments to implementing AMT's can be divided into five groups: cost-related problems, government policy, labour market imperfections, internal organization problems and imperfections in the market for information (Arundel, 1997; Baldwin & Lin, 2002). Sohal *et. al.* (2001), point out disruptions during implementation, failure to achieve financial targets and production management skill deficiencies as impediments.

Grant (1992), identifies five categories of resources: financial, physical, human, technological and reputation. Petra & Koenraad (2006), find it necessary to check for interaction effects between technological, financial, human and networking resources. Lefebvre et al. (1996), grouped intangible assets to form three sets of independent variables; *acquired technical capabilities* of the different categories of employees, influences of *internal and external proponents (process issues)* and *strategic motivations* for further AMT adoption. The CEO, marketing, engineering and production formed the internal influences while external influences include: consultants, suppliers of technologies, customers (Lefebvre *et. al.* 1996); tax incentives (Sanchez, 1991); environmental, safety or health concerns (Jimenez et. al., 1992; Sanchez, 1991). Schroder & Sohal (1999), found a significant relationship between the size of the firm and hierarchical level of human resource personnel involved in AMT idea generation. The firm size in this case is measured by the annual sales.

"Little research has addressed the competitive strategies of small manufacturing firms, particularly their motivations for AMT adoption and implementation" (Mechling *et. al.* 1995). This statement should apply to Uganda's case whose manufacturing firms mainly comprise of small to medium sized enterprises. The author knows of no research that has specifically studied AMT adoption patterns in Uganda. The effect education levels and technical skills have on the technological development, the main incentives for AMT adoption in existence and the types and degree of automation appropriate to the various categories of establishments in developing countries is not known. Last but not least, the literature provides overwhelming evidence that SME's are still an under investigated field of research but represent an important proportion of operating firms, contribute significantly to new job creation and to innovative activities and they have been shown to be increasingly active in export markets.

Indeed there is a great interplay among benefits, impediments and strategies as determinants of AMT penetration. However, it is evident that the decision to adopt advanced technologies ultimately rests on the benefits that the technology provides and the costs associated with its adoption (Baldwin & Lin, 2002). While the literature provides interesting insights into the determinants of AMT penetration there is still a potentially rich area of research for policy-makers, entrepreneurs, practitioners and academics interested in the correlates of AMT adoption and penetration in developing countries.

CHAPTER 3: RESEARCH METHODOLOGY

This chapter details the materials and methods used in this study to collect and analyse the data. The research design - which describes the nature and pattern the research followed is first presented. The method used for sampling and collecting the data is then presented. The dependent and independent variables that are used in the models presented in Chapter 4 are then introduced. Finally, the quality control measures are introduced before presenting the operationalisation of the hypotheses that are tested.

3.1 Research Design

This study is by a cross-sectional survey and the instrument used for collecting data is a questionnaire (see Appendix 1.0: Survey Instrument & Appendix 9.0 Validation 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.

3.2 Research Approach

The approach used in this study is quantitative in nature. The completely randomised sampling technique is used. The sampling frame used was 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. In order to track the representation of manufacturing activities, an ingredient to addressing hypothesis H_{o3}, the resulting sample is further categorized based on the firms' activities (see Table 1).

Table 1: Summary statistics for manufacturing activities

Stratification	Frequency	Percent	Cummulative
Food processing	12	30.77	30.77
Bottling industry	3	7.69	38.46
Textile industry	4	10.26	48.72
Chemical industry	1	2.56	51.28
Ceramic industry	1	2.56	53.85
Metal industry	18	46.15	100.00
Total	39	100.00	

Given the small size of the data set compounded with the fact that five of the seven dependent variables are count outcomes, nonparametric techniques are mainly employed in the analysis. However, logistic regression is used to analyze the dichotomous variable (user) and quantile or linear regression is used for the continuous variable (ratio).

3.3 Instruments

In this study a single tiered questionnaire is used as a primary data collection instrument (see Appendix 1.0: Survey Instrument & Appendix 9.0 Validation questionnaire). Only quantitative responses are collected. The responses comprised of continuous, ordinal and dichotomous datasets depending on the variable being measured.

The main statistical tools used for analysis are:

- Epidata software for data entry
- Intercooled Stata 8.2. for data analysis
- Microsoft Excel for computerised random sampling and smooth graph plotting

3.4 Operationalisation of Model Variables

Questions 1 and 2 of the survey instrument asked firms to identify the type of AMT's they had adopted (see Appendix 1.0: Survey Instrument). The AMTs were placed into two categories – integrative and managerial systems (IMS) and systems, devices and stations (SDS). A firm's breadth of adoption (AMT) will be the number of different types of advanced manufacturing technologies used by each firm. The survey instrument identified 25 possible such technologies. Thus for example, a firm's AMT can range from "0" (a firm which has no AMT) to "25" (a firm which has adopted all 25). In addition the survey instrument asked firms to identify the technologies they planned to adopt in the near future.

3.4.1 Measures of technological activity

The methodology set out to analyse seven different measures of technological activity in order to test the robustness of the hypotheses. These measures are used as the dependent variables in the regression models as expounded below:

user	-	This is a dichotomous variable taking a value of 1, if the plant uses any of the 25 technologies and 0, otherwise. This measure distinguishes technology users from non-users but does not take into account the intensity of technology use.
IMS	-	Measures the total number of integrative and managerial systems in use. This is a count variable reflecting the total number of software's that a firm uses and it ranges in value from 0 to 13.
SDS	-	This is also a count variable reflecting the total number of systems, devices and stations that a firm uses and it ranges in value from 0 to 12.
AMT	-	measures the total number of advanced technologies in use (IMS + SDS). This is a count outcome variable reflecting the total number of advanced technologies that a firm uses and it ranges in value from 0 to 25. This measure takes into account the intensity of technology use. Its form is expected to impose a monotonic relationship between the number of technologies in use and the regression variables.
expctd	-	measures the total number of advanced technologies, (IMS + SDS), that a firm expects to implement within the next three years. It ranges in value from 0 to 17.
breadth	-	this value takes on the mathematical form AMT + expctd.
ratio	-	this is the ratio of IMS to SDS. It measures the extent to which firm's are integrating their systems, devices and stations or hardware equipment. This is a continuous variable and it ranges in value from 0 to 1. By its nature it can be subjected to parametric techniques once normally distributed.

It should be noted that the first six measures essentially nest within each other, thereby allowing one to test whether capturing intensity as opposed to incidence of use matters.

3.4.2 Determinants of factors to advanced technology adoption

In order to examine the factors that are associated with AMT penetration, multivariate analysis is used to relate technological advancement to a set of firm characteristics such as size, nationality of ownership, type of ownership, location, employee educational levels, internal/external influences, strategic motivations, production activities, impediments, innovativeness, flexibility priorities, collaboration networks and machine shop capabilities. The regressions are performed for each of these predictors. Various data types are used for the independent variables (see Table 2)

In general additive regression modeling is used on continuous outcomes with particular emphasis on semi-parametric models in which some of the predictors enter linearly. Logistic regression is used for the binary outcomes whereas Poisson and negative binomial regression (nbreg) techniques are used for tests involving count outcomes which formed the majority of the outcomes.

3.5 Data quality control

In order to determine whether the data met the regression assumptions, regression diagnostics were used. These mainly comprised of:

- The Cronbach's alpha coefficient - used too check the reliability of the instrument
- Examination of data for validity
- Detecting unusual and influential data
- Testing for normality of Residuals and performing the necessary transformations
- Checking the construct reliability of the data variables
- Checking for co linearity of predictor variables
- Checking for linearity between the determinants and predictors
- Checking for the independence of predictors
- In addition post regression tests were perform after every regression and included:

- Alkaike information criteria (AIC) – used to check the best fit among models incorporating continuous variables.
- Link tests – used to obtain _hat and _hatsq which detect model specification errors.
- Multivariate fractional polynomial - selects the fractional polynomial (FP) model which best predicts the outcome variable when continuous variables are incorporated into the model.

Table 2: Description of independent variables

Predictor	Data type	Explanation
Size	Continuous	Measured by the no. of employees
Nationality of ownership	Nominal	Foreign/Locally owned
Type of ownership	Nominal	Sole proprietorship, private limited company, partnership
Location	Nominal	Central, Western, South western or Eastern
Employee education levels	Continuous	Percentage using computer based technologies
Internal/external influences	Ordinal	Likert scale 1-5
Strategic motivations	Ordinal	Likert scale 1-5
Production activity	Ordinal	Likert scale 1-5
Impediments	Dichotomous	Yes/ No
Innovativeness	Ordinal	Likert scale 1-5
Flexibility priorities	Dichotomous	Yes/No
Collaboration networks	Dichotomous	Yes/No
Machine tools	Continuous	Quantity of each machine tool
Manufacturing system	Continuous	Percentage of total jobs on each system
External services	Continuous	Percentage of jobs from external sources
Machine shop inadequacy	Continuous	Percentage of jobs rejected
Machine shop limitations	Dichotomous	Yes/No

3.6 Research Models

The study set out to test six hypotheses. This section states the null hypotheses and explains the methods used to test them.

***H_{01}*:** Technical skills of all groups of employees have no positive effect on the level of automation in the Ugandan machine tool driven industry.

The survey instrument (see Appendix 1.0: Survey Instrument), in question 4 measured the technical capabilities of the different categories of employees, as the actual percentage of employees within each category who used computer based technologies on a daily basis. The following multiple regression model is used to test hypothesis 1:

$$AMT_i = \beta_0 + \beta_1 (CE)_i + \beta_2 (SEC)_i + \beta_3 (MGR)_i + \beta_4 (ENG)_i + \beta_5 (BCW)_i + \varepsilon_i$$

Equation 1

Where AMT_i = breadth of AMT adoption of firm i, CE_i = percentage of clerical employees that use computer based technologies on a daily basis in firm i, SEC_i = percentage of secretaries that use computer based technologies on a daily basis in firm i, MGR_i = percentage of managers that use computer based technologies on a daily basis in firm i, ENG_i = percentage of engineers that use computer based technologies on a daily basis in firm i, BCW_i = percentage of blue collar workers that use computer based technologies on a daily basis in firm i. ε_i is the error term.

***H_{02}*:** Influences of internal and external proponents are not determinants of the level of automation in the Ugandan machine tool driven industry.

The variables here are measured on five-point Likert scales and are addressed in question 5 of the survey instrument (see Appendix 1.0: Survey Instrument), as follows: "*On a scale of 1-5 indicate how the following groups, individuals (MD) or factors (Government taxes) influence decisions to adopt AMT's in your firm.*". The influences though not indicated in the instrument, are categorized into two groups namely:

- External Influences
  - Tax incentives/favourable financing
  - Environment safety/health
  - Customers
- Internal Influences
  - Managing Director/Chief Executive Officer
  - Engineering/Production Department
  - Marketing/Sales Department

The following multiple regression model is used to test hypothesis 2:

$$AMT_i = \beta_0 + \beta_1 (TAX)_i + \beta_2 (ENV)_i + \beta_3 (CUST)_i + \beta_4 (MD)_i + \beta_5 (ENG)_i + \beta_6 (MRT)_i + \varepsilon_i$$

Equation 2

Where AMT_i = breadth of AMT adoption of firm i, TAX_i = firm i's response to tax incentives and/or favourable financing, $\underline{ENV_i}$ = firm i's response to environment, safety or health, $CUST_i$ = firm i's response to customers, MD_i = firm i's response to Managing director or Chief executive officer, ENG_i = firm i's response to Engineering/Production departments, MRT_i = firm i's response to Marketing/Sales department. ε_i is the error term.

H_{03}: There is no relationship between the firm configuration and the degree of automation in Ugandan firms.

This hypothesis tested the effect the type of manufacturing activity a firm is involved in had on AMT penetration and adoption. The type of manufacturing activity is obtained directly from the UBOS business register.

The following analysis of variance (ANOVA) model is used

$$y_{ij} = \mu + \alpha_1 + e_{ij}$$
$$H_0 : \alpha_1 = \alpha_2 = \ldots = \alpha_k = 0$$

Equation 3

Where y_{ij} is the i[th] firms breadth of AMT in the j[th] category of activity and α_{ij} is the effect due to i[th] firm.

In addition group mean comparison and proportional tests for independent samples among others are performed where applicable to test other aspects of firm configuration.

***H₀₄*:** There is no positive relationship between production strategies and the degree of automation within Ugandan machine tool driven firms.

The variables here are measured on five-point Likert scale and are addressed in question 6 of the survey instrument (Appendix 1.0: 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.*". The following multiple regression model is used:

$$\mathrm{AMT}_i = \beta_0 + \beta_1(PRDCT)_i + \beta_2(LBCT)_i + \beta_3(PRD)_i + \beta_4(PRDQT)_i + \beta_5(CUSTSQ)_i + \beta_6(DMRT)_i + \beta_7(FMRT)_i + \beta_8(CPADV)_i + \beta_9(FLX)_i + \varepsilon_i$$

Equation 4

Where AMT_i = breadth of AMT adoption of firm i, $PRDCT_i$ = firm i's response to reduction in cost of finished goods, $LBCT_i$ = firm i's response to reduction in labour costs, PRD_i = firm i's response to increase in overall productivity, $PRDQT_i$ = firm i's response to increased quality of product(s), $CUSTSQ_i$ = firm i's response to increased quality of customers services, $DMRT_i$ = firm i's response to increased domestic market share, $FMRT_i$ = firm i's response to increased foreign market share, $CPADV_i$ = firm i's response to superior firm image, FLX_i = firm i's response to increase in the flexibility of the manufacturing process. ε_i is the error term.

***H₀₅*:** 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 hypothesis 5

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

Equation 5

Where $(PS)_{ij}$= effect of firm i with dimension j of production strategy
$(TS)_{ik}$= effect of firm i with technical capability j and
$(PS)_{ij} \times (TS)_{ik}$=Interaction effects between strategic motivations and technical skills
TS and *PS* were obtained by taking the aggregated total of technical skills and production strategies.

H₀₆: Influences of proponents do not modify the form of the relationship between degree of automation and technical skills of employees in firms.

The following Multivariate regression model is used to test hypothesis 6

$$\text{AMT}_{ijk} = \beta_0 + \beta_1 (TS)_{ij} + \beta_2 (IP)_{ik} + \beta_3 (TS)_{ij} \times (IP)_{ik} + \varepsilon_i$$

Equation 6

Where $(TS)_{ij}$= effect of firm i with dimension j of technical skills
$(IP)_{ik}$= effect of firm i with influence of proponents k
$(TS)_{ij} \times (IP)_{ik}$=Interaction effects between technical skills and influences of proponents.
TS and *IP* were obtained by taking the aggregated total of technical skills and influences of proponents.

3.7 Validation

In addition to the pre and post regression diagnostics, a further validation exercise is taken. A survey instrument is administered to a panel of 14 experts in the mechanical industry (see Appendix 9.0 Validation questionnaire). The mainly significant results of the study are presented in the questionnaire with a view of obtaining an expert opinion regarding them.

CHAPTER 4: ANALYSIS AND PRESENTATION OF RESULTS

4.1 Distribution patterns of the dependent variables

The first six measures, with the exception of user, being essentially count outcomes would be expected to be positively skewed rendering parametric techniques inappropriate. Poisson regression is recommended for modelling these count variables provided the assumption that the conditional mean equals the conditional variance is met ("Analyzing Count Data", n.d.; , "Stata Data Analysis Examples", n.d.). If this dataset did not meet this assumption then other non parametric techniques were used as deemed fit.

Parametric techniques may be used for the variable ratio provided the data is normally distributed otherwise once again the Poisson regression is recommended.

The 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 ranging from 0.71 to 0.85 (see Table 45).

4.1.1 user variable

This variable takes a value of 1, if a firm reports use of any of the AMT's; the value of 0, otherwise. Since the dependent variable is dichotomous, the relationship is estimated with a logistic regression.

4.1.2 IMS variable

The IMS variable measures the depth of penetration of software forms of technologies in firms. It takes on a value in the range of zero (firm with no software technologies), to 13 (a firm that has implemented all 13 technologies). The data for IMS, (see Figure 3), is slightly skewed to the right, so clearly OLS regression would be inappropriate, so some type of Poisson analysis might be appropriate.

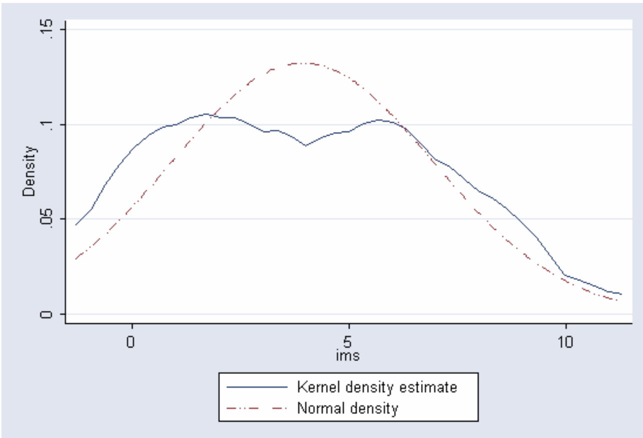

Figure 3: Frequency distribution of IMS

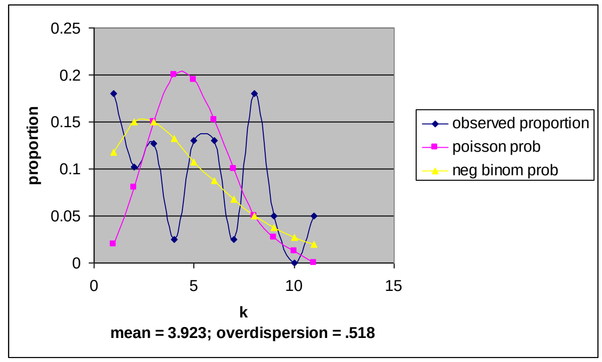

Figure 4: IMS (k) fit on Poisson and negative binomial distributions

The variance of IMS is nearly 3 times larger than the mean (see Table 46). The distribution of IMS is displaying signs of over dispersion, that is, greater variance than might be expected in a Poisson distribution.

A check to see how well the variable, IMS, fits both the Poisson and negative binomial distributions is displayed in Figure 4.

4.1.3 SDS variable

The SDS variable on the other hand measures the depth of penetration of hardware equipment related to AMT's in firms. It takes on a value in the range of zero (a firm with no hardware related technology), to 12 (a firm that has implemented all 12 technologies). The data for SDS, (see Figure 5), is skewed to the right, so clearly OLS regression would be inappropriate, so some type of Poisson analysis might be appropriate.

The variance of SDS is nearly two and half times larger than the mean which reinforces the Poisson regression approach (see Table 47). The skewness of 0.78 is too high for parametric techniques. A check to see how well the variable, SDS, fits both the Poisson and negative binomial distributions is next displayed (see Figure 6).

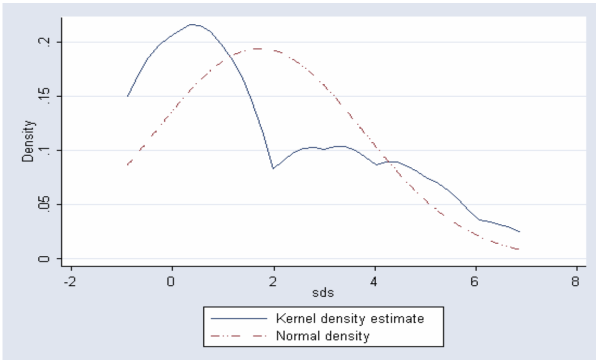

Figure 5: Frequency distribution of systems, devices and stations

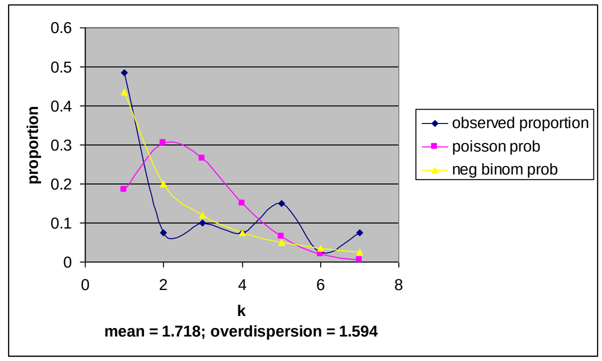

Figure 6: SDS (k) fit on Poisson and negative binomial distributions

4.1.4 AMT variable

AMT measures the combined depth of penetration of both software and hardware technologies related to AMT's in firms. It takes on a value in the range of zero (a firm with none), to 25 (a firm that has implemented all 25 technologies).The graphical data for AMT (see Figure 7) is strongly skewed to the right, so clearly OLS regression would be inappropriate, so some type of Poisson analysis might be appropriate.

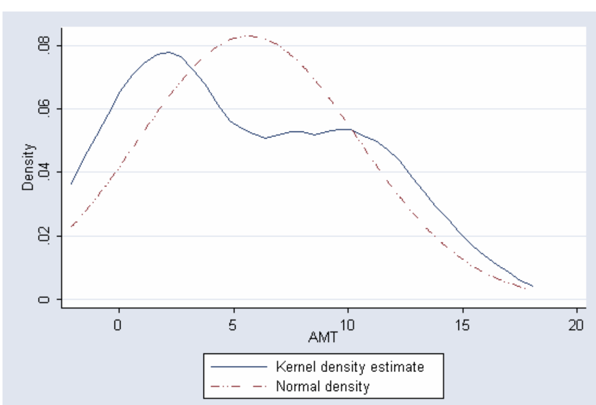

Figure 7: Frequency distribution of the AMT variable

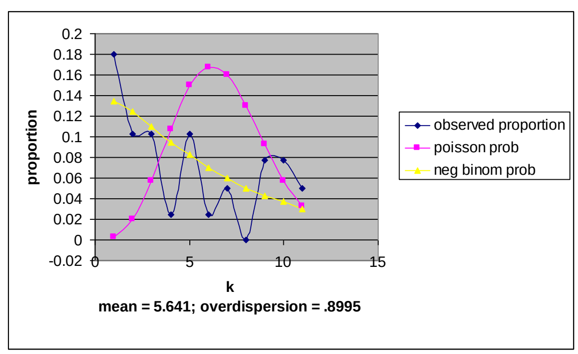

Figure 8: AMT (k) fit on Poisson and negative binomial distributions

The variance of AMT is nearly 5 times larger than the mean (see Table 48). The distribution of AMT is displaying signs of over dispersion, that is, greater variance than might be expected in a Poisson distribution.

A visual check to see how well the variable, **AMT**, fits both the Poisson and negative binomial distributions is displayed in Figure 8.

4.1.5 expctd variable

The expctd variable measure the firms plans for future investments in both hardware and software forms of technologies. It takes on a value in the range of zero (firm with no plans for investment), to 22. The data for expctd graphically displayed in Figure 9, is strongly skewed to the right so some type of Poisson analysis might be appropriate.

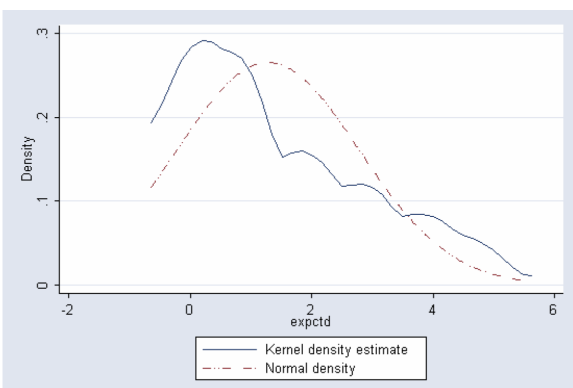

Figure 9: Frequency distribution of future plans for investment

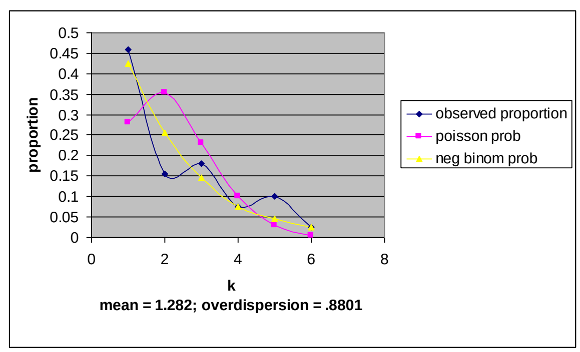

Figure 10: expctd (k) fit on Poisson and negative binomial distributions

The variance of expctd is nearly 2 times larger than the mean which suggests some type of Poisson analysis (see Table 49).The skewness of 0.874 renders OLS regression inappropriate.

The graphical check to confirm how well the variable, **expctd**, fits both the Poisson and negative binomial distributions is displayed in Figure 10.

4.1.6 breadth variable

The breadth variable measures a firm's current investment plus its future plans for investment in both software and hardware technologies related to AMT's. The data shown in Figure 11 for breadth is slightly skewed to the right, so clearly OLS regression would be inappropriate, so some type of Poisson analysis will be appropriate.

The variance of breadth is nearly 4 times larger than the mean (see Table 52). The distribution of breadth is therefore displaying signs of over dispersion, that is, greater variance than might be expected in a Poisson distribution. The graphical check to confirm how well the variable, **breadth**, fits both the Poisson and negative binomial distributions is displayed in Figure 12.

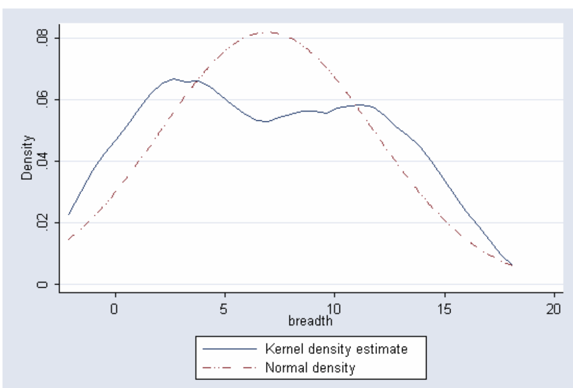

Figure 11: Frequency distribution for current investments and future plans

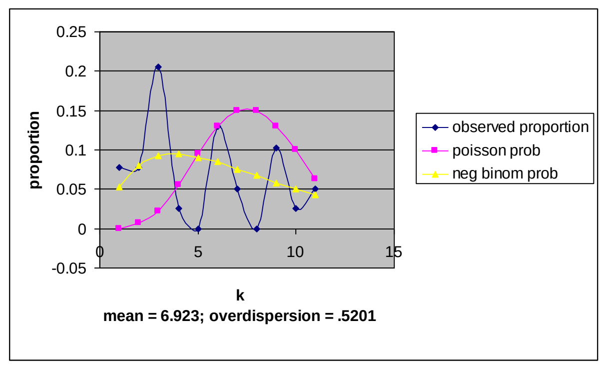

Figure 12: breadth (k) fit on Poisson and negative binomial distributions

4.1.7 ratio variable

This variable is the ratio of IMS to SDS that is software to hardware penetration. It is a measure of a firms integrative efforts and was used by Mechling *et. al.* (1995). The variable ratio being continuous could be analysed with parametric methods however the data in Figure 13 is strongly skewed to the right, so clearly OLS regression would be inappropriate for ratio in its current form.

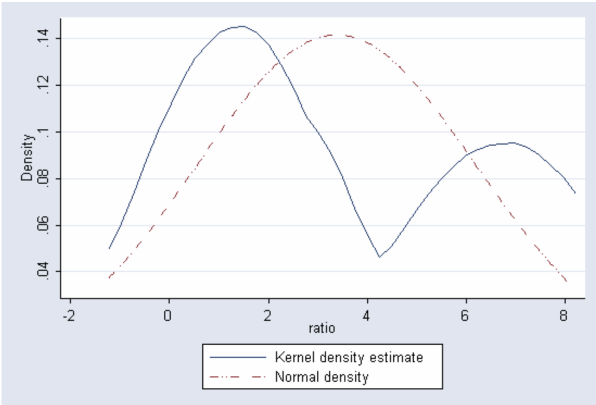

Figure 13: Frequency distribution of ratio

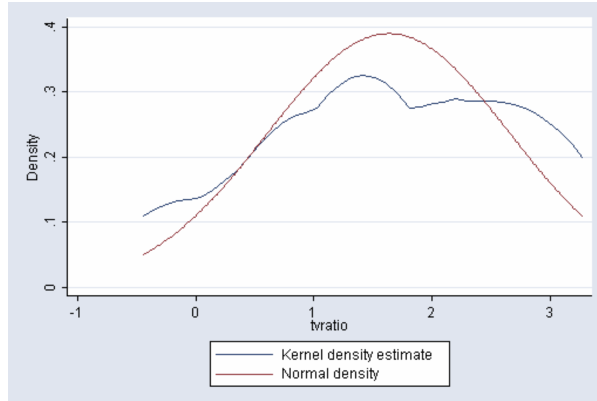

Figure 14: Kernel density plot for $\sqrt{ratio}$

The variance for ratio is about three times its mean (see Table 50). However, the variance is not substantially smaller than the mean and the predictor variables should help, so it may be reasonable to fit a quantile regression model if this variable is left in the current form.

4.2 Results from regression diagnostics

In the previous sections various methods for examining the distribution of the variables are used. This section verifies how well the data meets the assumptions of OLS regression in order to avoid misleading results. The data is found to be valid and without data entry errors. All the diagnostics are obtained by regression of the transformed dependant variable ratio against the predictors.

4.2.1 Transformation of ratio variable

The results of transforming ratio are shown in Table 3 and Figure 15.

The square root transform has the smallest chi-square. These results are verified graphically in the Figure 15 and Figure 14. The variance for $\sqrt{ratio}$ is about two-thirds its mean (see Table 51). However, the variance is not substantially smaller than the mean and the predictor variables should help, so it may be reasonable to fit a quantile regression model.

Table 3: Possible transformations for the ratio variable

Transformation	formula	$chi^2(2)$	P(chi2)
Cubic	$ratio^3$	17.69	0.000
Square	$Ratio^2$	20.17	0.000
Raw	Ratio	22.43	0.000
square-root	sqrt(ratio)	6.21	0.045

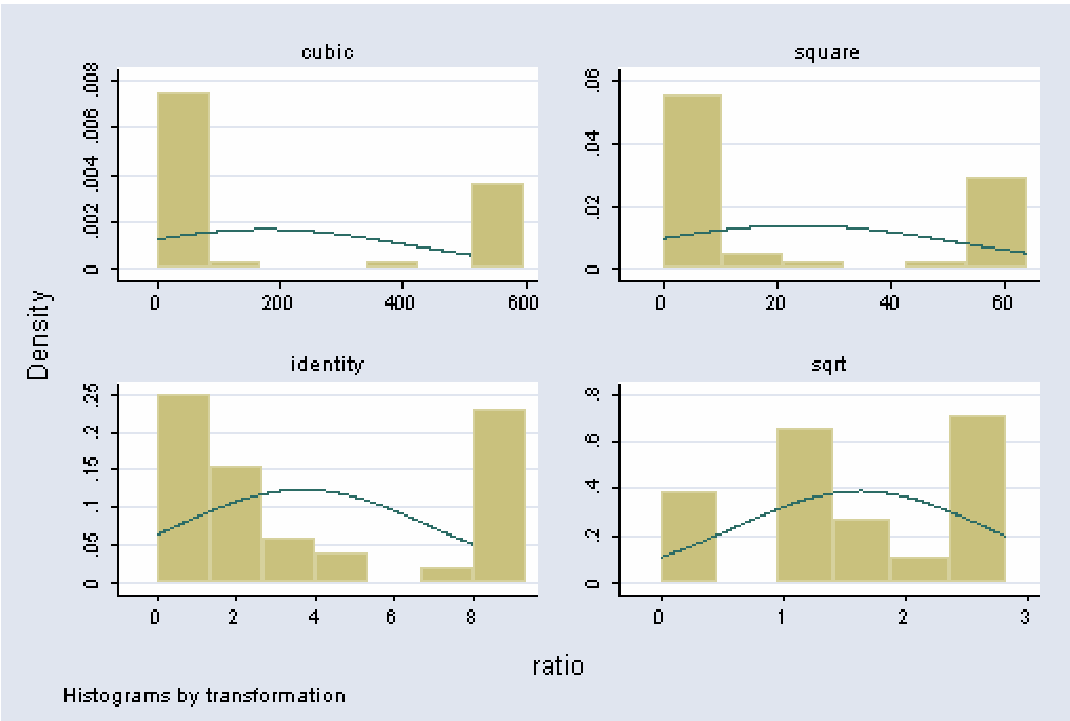

Figure 15: Graphical representation of the transformations on ratio

4.2.2 Transformation of Employee skills predictors

The categories of employees considered for this variable are given below:

- Clerical employees
- Secretaries
- Functional Managers
- Engineers and
- Blue collar workers

Using the same manipulations used to transform the ratio variable, the predictors in the category of employee skills are transformed to normality where necessary. The results are summarised in Table 4.

Table 4: Transformation of Employee skills' variables

Employee category	Lowest $chi^2(2)$	P(chi2)	Transformation	Formula
Clerical Employees	6.86	0.032	Identity	v4i
Secretaries	7.60	0.022	Square	$v4ii^2$
Functional Managers	6.79	0.034	Identity	V4iii
Engineers	31.13	0.000	Square-root	$\sqrt{v4iv}$
Blue collar workers	16.51	0.000	Square-root	$\sqrt{v4v}$

4.2.2.1 Checking normality of residuals

Since OLS regression requires that the residuals (errors) be identically and independently distributed ("Regression Diagnostics", n.d.). The normality of the residuals is checked by regressing the transformed continuous variable ratio against the transformed predictor variables under the employee skills category. The kernel density plot is shown in Figure 16.

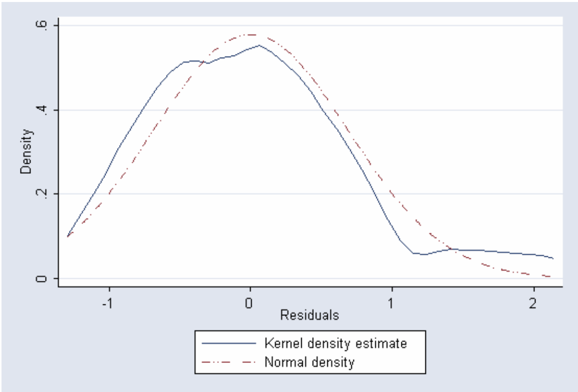

Figure 16: Kernel density plot of residuals of transformed employees skills

The Shapiro-Wilk W test for normality results are shown in Table 5. The p-value is based on the assumption that the distribution is normal. In this case, the p-value is significant (.026), indicating that the null hypothesis that the residuals are normally distributed is rejected.

Table 5: Shapiro-Wilk W test for normal data

Variable	Obs	W	V	Z	Prob>z
Residual	39	0.93483	2.526	1.947	0.02575

Table 6: Co-linearity Diagnostics for employee skills

Transformed Variable	VIF	SQRT VIF	Tolerance	R-Squared	Eigenval	Cond Index
ratio	1.94	1.39	0.5164	0.4836	5.6051	1.0000
Clerical Employees	3.54	1.88	0.2825	0.7175	0.7829	2.6757
Secretaries	2.76	1.66	0.3619	0.6381	0.2024	5.2623
Functional Managers	2.32	1.52	0.4308	0.5692	0.1528	6.0573
Engineers	2.01	1.42	0.4969	0.5031	0.1423	6.2764
Blue collar workers	1.61	1.27	0.6210	0.3790	0.0741	8.6998
Mean VIF	2.36				**Condition Number**	**11.7608**

Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)

Det(correlation matrix) 0.0615

4.2.2.2 Checking for multicollinearity of employee skills

The results for multi co-linearity diagnostics of the employee's skills are shown in Table 6. The variance inflation factors (VIF) are all less than 10 which mean that none of the variables could be considered as a linear combination of other independent variables. However, the index of the global instability of the regression coefficients used, has a condition number greater than 10 which is an indication of instability ("Regression Diagnostics", n.d.).

4.2.3 Transformation of Internal/External proponents

The internal and external influences considered are:

- External Influences
  - Tax incentives/favourable financing

  - Environment safety/health
  - Customers
- Internal Influences
  - Managing Director/Chief Executive Officer
  - Engineering/Production Department
  - Marketing/Sales Department

Manipulation of the predictors in the categories of internal and external influences produced the results in Table 7.

Table 7: Transformations of Internal/External influences

Internal/External Influence	Lowest $chi^2(2)$	P(chi2)	Transformation	Formula
Managing Director	19.73	0.000	Cubic	$v5i^3$
Engineering-Production	1.80	0.407	Square	$v5ii^2$
Marketing-sales	5.18	0.075	Square	$v5iii^2$
Customers	1.18	0.554	Cubic	$v5iv^3$
Environmental	5.73	0.057	Square	$v5v^2$
Tax incentives	1.46	0.483	Square	$v5vi^2$

4.2.3.1 Checking normality of residuals

The normality of the residuals is checked by regressing the transformed continuous variable ratio against the transformed predictor variables under internal/external proponents. The kernel density plot is shown in Figure 17.

The Shapiro-Wilk W test for normality results are shown in Table 8. In this is case, the p-value is very large (.26), indicating that the null cannot be rejected meaning that the residuals are normally distributed. Therefore OLS is applicable for this model.

Table 8 : Shapiro-Wilk W test for normal residuals

Variable	Obs	W	V	Z	Prob>z
Residual	39	0.96518	1.350	0.630	0.26420

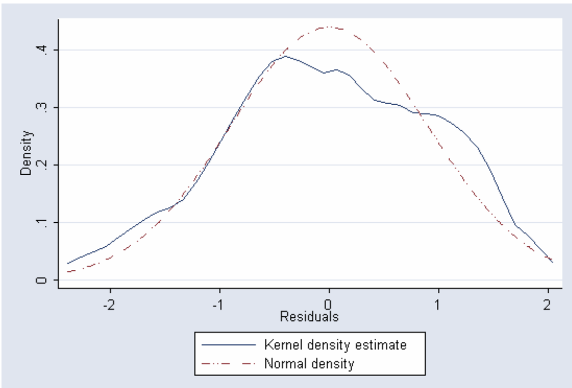

Figure 17: Kernel density plot for internal/external influences residuals

4.2.3.2 Checking for multicollinearity of internal/external proponents

Table 9: Collinearity Diagnostics for internal/external influences

Transformed Variable	VIF	SQRT VIF	Tolerance	R-Squared	Eigenval	Cond Index
ratio	1.12	1.06	0.8934	0.1066	6.1643	1.0000
Managing Director	1.34	1.16	0.7461	0.2539	0.4919	3.5398
Engineering-Production	1.10	1.05	0.9095	0.0905	0.4536	3.6863
Marketing-sales	1.19	1.09	0.8393	0.1607	0.3160	4.4167
Customers	1.20	1.10	0.8336	0.1664	0.2284	5.1946
Environmental	1.06	1.03	0.9471	0.0529	0.2039	5.4987
Tax incentives	1.08	1.04	0.9268	0.0732	0.1207	7.1472
Mean VIF	1.16				**Condition Number**	17.0663

Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)
Det(correlation matrix)   0.6302

The results for multi collinearity diagnostics of internal/external proponents are shown in Table 9. The variance inflation factors (VIF) are all less than 10 which mean that none of the variables could be considered as a linear combination of other independent variables. However, the index of the global instability of the regression coefficients used, has a condition number greater than 10 which is an indication of instability ("Regression Diagnostics", n.d.).

4.2.4 Transformation of Strategic motivations

Table 10: Transformations of strategic motivation predictors

Strategic motivation	Lowest $chi^2(2)$	P(chi2)	Transformation	Formula
Reduction in product costs	3.32	0.190	identity	v6i
Reduction in labour costs	0.23	0.890	Identity	v6ii
Increase in overall productivity	3.98	0.137	Identity	v6iii
Increased quality of products	4.83	0.089	Square	$v6iv^2$
Increased quality of customer services	4.85	0.089	Square-root	$\sqrt{v6v}$
Increased domestic market share	6.52	0.038	Reciprocal root	$\frac{1}{\sqrt{v6vi}}$
Increased foreign market share	9.34	0.009	Cubic	$v6vii^3$
Superior firm image	5.77	0.056	Natural log	*ln*(v6viii)
Increased flexibility of manufacture	6.77	0.034	Square	$v6ix^2$

The categories of strategic motivations considered are:

- Reduction in cost of finished product(s)
- Reduction in labour costs
- Increase in overall productivity
- Increase in quality of product(s)
- Increase in quality of customer services
- Increased domestic market share
- Increased foreign market share

– Superior image of the firm
– Increase in the flexibility of the manufacturing process

Manipulation of these predictors in these categories produced the results in Table 10.

4.2.4.1 Checking normality of residuals

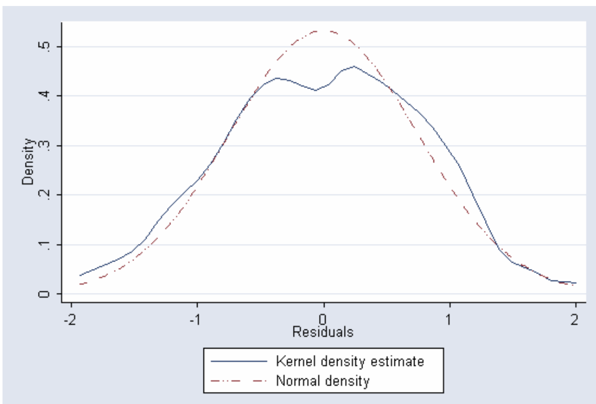

Figure 18: Kernel density plot for strategic motivations' residuals

The normality of the residuals is checked by regressing the transformed continuous variable ratio against the transformed predictor variables under strategic motivations. The kernel density plot is shown in Figure 18.

Table 11: Shapiro-Wilk W test for normal residual data

Variable	Obs	W	V	Z	Prob>z
Residual	39	0.97961	0.790	-0.495	0.68957

The Shapiro-Wilk W test for normality results are shown in Table 11. In this case, the p-value is very large (.69), indicating that we cannot reject the null hypotheses that the residuals are normally distributed. Therefore OLS regression is appropriate in this case.

4.2.4.2 Checking for multicollinearity of Strategic motivations

The results for multi co-linearity diagnostic for strategic motivations are shown in Table 12. The variance inflation factors (VIF) are all less than 10 which mean that none of the variables could be considered as a linear combination of other independent variables. However, the index of the global instability of the regression coefficients used, condition number is much greater than 10 which is an indication of instability ("Regression Diagnostics", n.d.).

Table 12: Collinearity Diagnostics for strategic motivations

Transformed Variable	VIF	SQRT VIF	Tolerance	R-Squared	Eigenval	Cond Index
ratio	1.64	1.28	0.6108	0.3892	9.1662	1.0000
Reduction in product costs	1.75	1.32	0.5710	0.4290	0.6401	3.7843
Reduction in labour costs	1.36	1.17	0.7335	0.2665	0.4316	4.6085
Increase in overall productivity	1.69	1.30	0.5933	0.4067	0.2855	5.6667
Increased quality of products	2.75	1.66	0.3632	0.6368	0.1866	7.0090
Increased quality of customer services	2.20	1.48	0.4542	0.5458	0.1214	8.6900
Increased domestic market share	1.74	1.32	0.5749	0.4251	0.0641	11.9554
Increased foreign market share	2.28	1.51	0.4392	0.5608	0.0420	14.7744
Superior firm image	1.50	1.23	0.6647	0.3353	0.0317	16.9950
Increased flexibility of manufacture	1.47	1.21	0.6811	0.3189	0.0249	19.1919
Mean VIF	1.84				**Condition Number**	39.1552

Eigenvalues & Cond Index computed from scaled raw sscp (w/ intercept)

Det(correlation matrix) 0.0422

4.2.5 Unusual and Influential data

Table 13 shows results of diagnostics that identified predictors that were outliers and those that exerted leverage on the continuous determinant ratio. The Cook's D and DFITS measures are used to identify the observations with high influence. A check is then performed to identify which percentile these observations lie thus selecting a suitable regression about the median.

Table 13: Outliers, leverage and influence among predictors

	No of Observations		**Firms' id number**		
Predictor variables	**Absolute Studentized Residuals > 2.0**	**Leverage > 0.308**	**Cooks D > 4/n**	**Absolute DFITS > 2*sqrt(k/n)**	**Recommended technique for continuous**
Employee skills	2	3	- 1 19 8	4 1 19 8	Quantile (90%)
Internal & external Influences	2	2	- 29 11 5 19	2 29 11 5 19	Quantile (50%)
Strategic motivations	4	8	35 11 15 2	35 11 15 2	Quantile (75%)

Where

k = number of predictors

n = number of observations

4.3 Significance Testing

Significance of a model and thus rejection of the stated hypotheses is mainly based on the following observations from the tests at a 95% confidence interval:

<u>Model fitting</u>

Probability of Chi^2 (χ^2) – For the model to be significant this value should be less than 0.05.

Pseudo R^2 values – this is the proportion of the variation in the dependent variable that is explained by the explanatory variables (high R^2 would imply less noisy variation).

Goodness of fit probability – Used to test whether the model fits reasonably well. If this test is statistically significant, it would indicate that the data does not fit the model well. The null hypotheses will be accepted if this value is below 0.05. This is only applicable to models that have used the Poisson regression.

The Akaike information criterion (AIC) is a measure of the relative goodness of fit of a statistical model. It is grounded in the concept of information entropy, in effect offering a relative measure of the information lost when a given model is used to describe reality. It can be said to describe the tradeoff between bias and variance in model construction, or loosely speaking between accuracy and complexity of the model. Given a set of candidate models for the data, the preferred model is the one with the minimum AIC value. ("Akaike information criterion", n.d.). Therefore,

- $AIC = \chi 2 + 2k$ is used for model comparisons – lowest value is picked.

Model coefficients

The coefficients of the resulting model are then picked based on whether they satisfy the following observations

- 95% confidence interval (C.I.) or p-value < 0.05 and
- Standard error < 3.0

The method used to detect specification errors is based on the idea that if a regression is properly specified, one should not be able to find any additional independent variables that are significant except by chance. Two new variables are created, the variable of prediction, *_hat*, and the variable of squared prediction, *_hatsq*. The model is then refitted using these two variables as predictors**.** *_hat* should be significant since it is the predicted value. On the other hand, *_hatsq* shouldn't, because if the model is specified correctly, the squared predictions should not have much explanatory power ("Regression Diagnostics", n.d.). Therefore,

- variable of prediction, *_hat* < 0.05 (significant)
- Squared variable of prediction, *_hatsq* > 0.05 (not significant)

4.4 Role of Intangible Assets on AMT adoption

The assets that were considered to be intangible were employee skills, strategic motivations, flexibility strategies, internal and external influences and technical collaboration partners.

4.4.1 Employee skills

A good starting point would be a presentation of the statistics from the raw data for this category of variables. It is evident that the biggest users of computer-based technologies on a daily basis and therefore more skilled technically are the secretaries followed by the functional managers (see Table 53).

A test is first taken for independence of all categories of employee skills. The null hypothesis is that the level of technical skills is the same for all these categories of employees with the alternate hypothesis being that the level is not the same. The Kruskal-Wallis test or the H-test is used to check for independence (see Table 14).

Table 14: Test for equality of employee skills categories

Employee category	**Observations**	**Rank Sum**
Clerical employees	39	4185.50
Secretaries	39	4809.00
Functional Managers	39	4471.50
Engineers	39	3893.00
Blue collar workers	39	1751.00

chi-squared = 46.872 with 4 d.f.
probability = 0.0001

chi-squared with ties = 53.448 with 4 d.f.
probability = 0.0001

It is obvious that the level of technical skills in industry is not the same for all these categories. The question to be addressed at this point is whether they positively or negatively have an impact on AMT adoption; in what form and to what extent. Thus the following analysis proceeds.

4.4.2 Contribution of employee skills to AMT adoption

The first hypothesis sought to test whether technical skills of all groups of employees had any effect on the level of automation in the Ugandan machine tool industry.

The following multiple regression model was used to test this hypothesis:

$$\text{Dependent} = \beta_0 + \beta_1 (CE)_i + \beta_2 (SEC)_i + \beta_3 (MGR)_i + \beta_4 (ENG)_i + \beta_5 (BCW)_i + \varepsilon_i$$

Equation 7

Where AMT_i = breadth of AMT adoption of firm i, CE_i = percentage of clerical employees that use computer based technologies on a daily basis in firm i, SEC_i = percentage of secretaries that use computer based technologies on a daily basis in firm i, MGR_i = percentage of functional managers that use computer based technologies on a daily basis in firm i, ENG_i = percentage of engineers that use computer based technologies on a daily basis in firm i, BCW_i = percentage of blue collar workers that use computer based technologies on a daily basis in firm i. ε_i is the error term.

4.4.2.1 Role of employee skills on user

The dependent variable ‘user’ being dichotomous, logistic regression is used to test whether the level of technical skills has any effect on firms’ applying any form of AMT. The model (see Table 61) is not statistically significant so we do not reject the null hypothesis for this variable. Therefore the level of technical skills of various categories of employees has no effect on whether a firm uses AMT’s or not.

4.4.2.2 Role of employee skills on IMS

The variance of IMS is nearly 3 times larger than the mean (see Table 46). However the negative binomial regression method presented the same results as the Poisson technique.

The Poisson model, as a whole, is statistically significant at a 95% confidence interval for the coefficients (see Table 56). **MGR** and **ENG** are statistically significant with coefficients of 1.07 and 0.93 respectively and p-values of 0.014 and 0.003 respectively. This means that the expected change in the log count for a one-unit increase in MGR is 1.07 and ENG is 0.93. However, the multivariable fractional polynomial (MFP) model produces a lower AIC as well as a better goodness of fit (see Table 63).

The above analysis results in the following resultant MFP model:

$$\ln(ims_i) = 1.43 - 0.255 \times CE_i + 0.692 \times SEC_i + 0.974 \times MGR_i - \frac{0.007}{ENG^2} + 0.167 \times BCW_i$$

Equation 8

Where ims_i = Integrative and managerial systems in firm i, CE_i = percentage of clerical employees that use computer based technologies on a daily basis in firm i, SEC_i = percentage of secretaries that use computer based technologies on a daily basis in firm i, MGR_i = percentage of functional managers that use computer based technologies on a daily basis in firm i and ENG_i = percentage of engineers that use computer based technologies on a daily basis in firm i and BCW_i = percentage of blue collar workers that use computer based technologies on a daily basis in firm i.

4.4.2.3 Role of employee skills on SDS

The variance of SDS is over 2 times larger than the mean (see Table 47). However the negative binomial regression method presented similar results to the Poisson technique. The Poisson model (see Table 57), as a whole, is quite significant at a 95% confidence interval for the coefficients with 45% of the variation in SDS being explained by the predictor variables. The goodness of fit at 0.55 is good. **CE, MGR** and **BCW** are statistically significant with coefficients of -1.26, 2.76 and 1.29

respectively and p-values of 0.014, 0.017 and 0.000 respectively. However, the MFP model produces a lower AIC as well as a better goodness of fit (see Table 63)

4.4.2.4 Role of employee skills on AMT

The variance in this case is about five times the mean for AMT thereby showing signs of over dispersion (see Table 48).

The model, as a whole, is statistically significant with a pseudo-R^2 value of 0.43 (see Table 58). A significant ($p<0.05$) test statistic from the **gof** indicates that the Poisson model is inappropriate. **MGR, ENG** and **BCW** are statistically significant with coefficients of 1.41, 0.99 and 0.50 respectively and p-values of 0.003, 0.005 and 0.035 respectively. Using negative binomial distribution the likelihood-ratio test of the over-dispersion parameter alpha was not statistically significant (prob >= $chibar^2$ = 0.267), which suggests that Poisson regression was still a more appropriate model.

Checking the MFP model, a lower AIC as well as a better goodness of fit is observed (see Table 63), thereby giving it the best fit.

4.4.2.5 Role of employee skills on expctd

The variance for ‘expctd’ is about twice the mean so Poisson analysis could be appropriate (Table 49).

The model is not significant and therefore the null hypothesis is not rejected for this variable. The multivariable fractional polynomial (MFP) model doesn’t improve the situation (see Table 63). It also doesn’t even fit well with the Poisson distribution as well as with the negative binomial distribution (see Table 62).

4.4.2.6 Role of employee skills on breadth

This variable showed some amount of over dispersion with a variance about 4 times that of the mean (see Table 52).

The Poisson regression model (see Table 59), as a whole, is statistically significant with a pseudo-R^2 value of 0.40. A non significant ($p>0.05$) test statistic from the **gof** indicates that the Poisson model is appropriate. **SEC, MGR, ENG** and **BCW** are statistically significant with coefficients of 1.03, 0.86, 0.71 and 0.43 respectively and p-values of 0.014, 0.007, 0,004 and 0.019 respectively. Using negative binomial distribution the likelihood-ratio test of the over-dispersion parameter alpha was not statistically significant (prob >= $chibar^2$ = 0.500), which suggests that Poisson regression is still a more appropriate model. However, the MFP model produces a lower AIC as well as a much better goodness of fit (see Table 63), thereby giving it the best fit. The null hypothesis is therefore rejected.

4.4.2.7 Role of employee skills on ratio

This is a continuous variable with a variance about the same value as the mean (see Table 50 & Table 51) and thus there is no sign of over dispersion. Quantile regression (90%) is used as recommended earlier (see Table 13).

The model is statistically significant with the variation in ratio explained 21% of the time (see Table 60). The statistically significant variables are **CE, SEC** and **BCW** with coefficients of 1.20, -1.35 and -1.74 respectively and p-values of 0.000, 0.032 and 0.002 respectively. These figures indicate that these categories of employees play a role positive or negatively in the integration of systems devices and stations.

4.4.3 Summary of results of employee skills on AMT adoption

Table 15 shows the summary of results of regression of employee skills on AMT adoption for the full model. The categories of employees within firms that play a significant role positive or negative on different measures of technological activities are also presented (see Table 16).

Table 15: Summary of employee skills against dependant variables

<table>
<tr><th>Dependant variable</th><th>Pseudo-R^2</th><th>P-value gof</th><th>Significant variables</th><th>P-values</th><th>Coeff.</th><th>Null hypothesis</th><th>Model</th></tr>
<tr><td>user</td><td>35.20%</td><td>-</td><td>-</td><td>-</td><td>-</td><td>Accepted</td><td>Insignificant</td></tr>
<tr><td>IMS</td><td>35.56%</td><td>46.08%</td><td>MGR
ENG</td><td>0.030
0.000</td><td>0.974
-.007</td><td>Rejected</td><td>Okay</td></tr>
<tr><td colspan="8">$\ln(ims_i) = 1.43 - 0.255 \times CE_i + 0.692 \times SEC_i + 0.974 \times MGR_i - \frac{0.007}{ENG^2} + 0.167 \times BCW_i$</td></tr>
<tr><td>SDS</td><td>48.88%</td><td>84.51%</td><td>CE
MGR
ENG
BCW</td><td>0.008
0.006
0.001
0.000</td><td>-1.18
2.87
-0.02
1.28</td><td>Rejected</td><td>Good</td></tr>
<tr><td colspan="8">$\ln(ims_i) = 0.10 - 1.176 \times CE_i + 1.344 \times SEC_i + 2.867 \times MGR_i - \frac{0.021}{ENG^2} + 1.284 \times BCW_i$</td></tr>
<tr><td>AMT</td><td>47.29%</td><td>9.71%</td><td>CE
MGR
ENG
BCW</td><td>0.044
0.005
0.000
0.005</td><td>-0.54
1.36
-0.01
0.56</td><td>Rejected</td><td>Poor fit with Poisson and negative binomial</td></tr>
<tr><td colspan="8">$\ln(ims_i) = 1.71 - 0.540 \times CE_i + 0.855 \times SEC_i + 1.359 \times MGR_i - \frac{0.008}{ENG^2} + 0.561 \times BCW_i$</td></tr>
<tr><td>expctd</td><td>4.62%</td><td>0.03%</td><td>None</td><td>-</td><td>-</td><td>Accepted</td><td>insignificant</td></tr>
<tr><td>breadth</td><td>39.68%</td><td>14.53%</td><td>CE
SEC
MGR
ENG
BCW</td><td>0.016
0.017
0.008
0.000
0.011</td><td>-0.47
1.00
0.77
-0.01
0.41</td><td>Rejected</td><td>Okay</td></tr>
<tr><td colspan="8">$\ln(ims_i) = 1.97 - 0.475 \times CE_i + 1.000 \times SEC_i + 0.773 \times MGR_i - \frac{0.006}{ENG^2} + 0.414 \times BCW_i$</td></tr>
<tr><td>ratio</td><td>21.10%</td><td>-</td><td>CE
SEC
BCW</td><td>0.001
0.000
0.000</td><td>1.20
-1.35
-1.75</td><td>Rejected</td><td>Okay</td></tr>
<tr><td colspan="8">$\sqrt{ratio_i} = 1.20 \times CE_i - 1.349 \times SEC_i^2 - 1.748 \times \sqrt{BCW_i} + 2.973$</td></tr>
<tr><td colspan="4">Key:</td><td colspan="4">MGR – Functional Managers</td></tr>
<tr><td colspan="4">CE – Clerical Employees</td><td colspan="4">ENG – Engineers</td></tr>
<tr><td colspan="4">SEC – Secretaries</td><td colspan="4">BCW – Blue collar workers</td></tr>
</table>

The implications of the statistical results and models presented in Table 15 become apparent when one looks at them simultaneously with their effect on the outcome variables as presented in Table 16. These thus, as presented in Table 15, form the categories of employees that significantly influence adoption patterns of AMTs.

Table 16: Categories of employees with significant impacts

	Clerical Employees	Secretaries	Functional Managers	Engineers	Blue Collar Workers
Users of any AMT					
Integrative and Managerial Systems (IMS)			*	*	
Systems, Devices and Stations (SDS)	◘		*	*	*
Intensity of use (AMT)			*	*	*
Investment plans (Expctd)					
Intensity and plans (AMT + Expctd)		*	*	*	*
Integration $\left(\frac{IMS}{SDS}\right)$	*	◘			◘

Key:

* - Positive significant impact
◘ - Negative significant impact

4.4.4 Internal and External Influences

The statistics from the raw data for this category of variables is presented in Appendix 8.0 Descriptive statistics. From the values presented one would expect the Managing Director/CEO to have a strong influence on AMT adoption followed by Engineering and production functions (see Table 54).

A test was first taken for independence of all categories of influences. The null hypothesis is that there is no difference in the effect of internal and external influences in the firm's with the alternate hypothesis being that the effect is different. The Kruskal-Wallis test or the H-test is used to test for independence.

Clearly internal and external influencing groups do not have the same effect in industry (see Table 17). The question to be addressed is whether they positively or negatively have an impact on AMT adoption; in what form and to what extent. Thus the following analysis proceeded.

Table 17: Test: Equality of influencing groups (Kruskal-Wallis test)

Category	Observations	Rank Sum
Customers	39	3899.50
Engineering- Production	39	5483.00
Environmental	39	3485.50
Managing director	39	7401.00
Marketing-sales	39	2979.00
Tax incentives	39	4247.00

chi-squared = 73.348 with 5 d.f.
probability = 0.0001

chi-squared with ties = 77.226 with 5 d.f.
probability = 0.0001

4.4.4.1 Effect of Internal and External influences on AMT adoption

The second hypothesis sought to find out whether the influences of internal and external proponents had an effect on the level of automation in the Ugandan machine tool industry.

The following multiple regression model is used to test hypothesis 2:

$$\text{Dependant}_i = \beta_0 + \beta_1 (TAX)_i + \beta_2 (ENV)_i + \beta_3 (CUST)_i + \beta_4 (MD)_i + \beta_5 (ENG)_i + \beta_6 (MRT)_i + \varepsilon_i$$

Equation 9

Where TAX_i = firm i's response to tax incentives and/or favourable financing, ENV_i = firm i's response to environment, safety or health, $CUST_i$ = firm i's response to customers, MD_i = firm i's response to Managing director or Chief executive officer, ENG_i = firm i's response to Engineering/Production departments, MRT_i = firm i's response to Marketing/Sales department. ε_i is the error term.

4.4.4.2 Role of internal and external influences on users of AMT's

Logistic regression is used to test whether the level of transformed influences of proponents have any effect on firms' applying any form of AMT.

All of the variables with the exception of the managing director and environmental aspects are not significant with all p-values > 0.05 (see Table 66). The model as a whole is statistically significant p> chi^2= 0.0141. Therefore at a 95% confidence interval the null hypothesis is rejected for this variable. The conclusion is that internal and external influences have a partial effect on whether firms' utilise AMT's or not.

4.4.4.3 Role of internal and external influences on IMS

Poisson regression is used for this test (see Table 67). The model as a whole is statistically significant with approximately 23% of the variation in IMS explained by the independent variables. It doesn't fit well with the Poisson distribution gof = 0.0024. The likelihood-ratio test of the over-dispersion parameter alpha is not statistically significant (prob >= $chibar^2$ = 0.266), which suggests that Poisson regression is a more appropriate model. The Managing Director/CEO, Engineering and/or production as well as Environmental issues significantly and positively impacted on the level of adoption of integrative and managerial systems in Ugandan firms.

4.4.4.4 Role of internal and external influences on SDS

Poisson regression is used to test the effect of internal and external influences on usage of systems, devices and stations in firms (see Table 68).

The model as a whole is statistically significant with approximately 26% of the variation in SDS explained by the independent variables. It does not fit well with the Poisson distribution gof = 0.0010. The likelihood-ratio test of the over-dispersion parameter alpha is not statistically significant (prob >= $chibar^2$ = 0.121), which suggests that Poisson regression is a more appropriate model. The Managing Director, Engineering and/or production departments and Environmental issues positively impacted on the level of adoption of systems devices and station in firms while Tax incentives/favourable financing significantly impacted on this variable negatively. The null hypothesis is rejected but it is noted that the model doesn't fit well.

4.4.4.5 Role of internal and external influences on AMT

The Poisson analysis for this regression gave a gof p-value = 0.000 rendering it inappropriate. This result is confirmed by the visual check on the fit on the Poisson vis-à-vis binomial regression for this dependent variable (see Figure 8).

Using the negative binomial analysis the model as a whole was statistically significant with approximately 10% of the variation in AMT explained by the independent variables (see Table 69). The regression did not fit well with the Poisson distribution. The likelihood-ratio test of the over-dispersion parameter alpha is statistically significant (prob >= $chibar^2$ = 0.000), which further verifies that Poisson regression is inappropriate. The influences of the Managing Director/CEO, Engineering and/or production departments and Environmental issues significantly impacted positively on the level of adoption of advanced manufacturing technologies in general in firms.

4.4.4.6 Role of internal and external influences on planned investments

Both Poisson and negative binomial analysis revealed weak models analytically, which can also be verified visually (see Figure 10).

With the Poisson analysis only tax incentives/favourable financing is significant with respect to investment plans among Ugandan firms (see Table 70). The goodness of fit is poor and the variation in the dependant variable is only explained approximately 13% by the independent variables. The null hypothesis is therefore rejected for this case. As a consequence it can be concluded that external influences in particular favourable financing and tax incentives are determinants to the plans for future investments in AMT's.

4.4.4.6 Role of internal and external influences on current and future investments

The model is significant but did not fit the Poisson distribution with a gof p-value of 0.0000. Using the negative binomial regression the Managing Director/CEO, Engineering and/or production departments as well as Environmental issues had a significant and positive impact on the current investments and future plans for investment in AMT's (see Table 71).

4.4.4.7 Role of internal and external influences on ratio of IMS to SDS

Median regression (50%) as earlier recommended is used for this analysis (see Table 13). The results for this analysis show that the model is significant with Managing director, Marketing/sales, Customers and tax incentives influenced firms' use of integrative and managerial systems on their systems, devices and stations (see Table 72).

However, from the *_hat* and *_hatsq* p-values of both the quantile and MFP analysis the model is not properly specified for this case (see Table 72). The median regression model indicates that the squared predictions have much explanatory power where as the MFP model points to an insignificant predicted value ("Regression Diagnostics", n.d.).

4.4.5 Summary of results of internal/external influences on adoption

Table 18 shows the summary of results of regression of internal and external influences on AMT adoption for the full model. The categories of proponents within Ugandan firms that play a significant role positive or negative on different measures of technological activities are also presented (see Table 19). The implications of the statistical results and models presented in Table 18 become apparent when one looks at them in tandem with their effect on the outcome variables as presented in Table 19. These thus, as presented in Table 19, form the groups, individuals or factors that significantly influence adoption of AMTs.

Table 18: 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	24.54%	-	MD ENV	0.046 0.007	0.03 0.15	Rejected	Significant
Ims	23.33%	0.24%	MD ENG ENV	0.000 0.016 0.000	0.02 0.04 0.04	Rejected	Poor fit with Poisson and negative binomial
$\ln(ims_i) = 0.017 \times MD^3_i + 0.040 \times ENG^2_i + 0.010 \times MRT^2_i + 0.000 \times CUST^3 + 0.039 \times ENV^2 - .059 \times TAX^2 - 1.621$							
Sds	26.15%	0.10%	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
$\ln(sds_i) = 0.029 \times MD^3_i + 0.042 \times ENG^2_i + 0.022 \times MRT^2_i - 0.007 \times CUST^3 + 0.038 \times ENV^2 - .054 \times TAX^2 - 3.449$							
AMT	9.97%	-	MD ENG ENV	0.001 0.018 0.001	0.02 0.05 0.04	Rejected	Significant
$\ln(AMT_i) = 0.019 \times MD^3_i + 0.049 \times ENG^2_i + 0.020 \times MRT^2_i - 0.004 \times CUST^3 + 0.041 \times ENV^2 - .016 \times TAX^2 - 1.589$							
expctd	12.96%	0.34%	TAX	0.010	0.05	Rejected	significant with poor fit
$\ln(\exp ctd_i) = 0.002 \times MD^3_i - 0.043 \times ENG^2_i + 0.039 \times MRT^2_i - 0.012 \times CUST^3 + 0.020 \times ENV^2 + .053 \times TAX^2 - 0.15$							
breadth	11.15%	-	MD ENG ENV	0.000 0.035 0.000	0.016 0.032 0.036	Rejected	Significant
$\ln(breadth_i) = 0.016 \times MD^3_i + 0.032 \times ENG^2_i + 0.022 \times MRT^2_i - 0.006 \times CUST^3 + 0.036 \times ENV^2 - .007 \times TAX^2 - 0.667$							
Ratio	16.07%	-	MD MRT CUST TAX	0.000 0.032 0.042 0.000	0.022 -0.041 0.009 0.058	Rejected	Significant with median regression
$\sqrt{ratio}_i = 0.022 \times MD^3_i 0.017 \times ENG^2_i - 0.041 \times MRT^2_i + 0.009 \times CUST^3 - 0.013 \times ENV^2 + .0058 \times TAX^2 - 1.175$							

Table 19: Internal/external proponents of AMT adoption

	Managing Director MD/CEO	Engineering or Production Departments	Marketing or sales Departments	Customers	Environmental or safety	Tax incentives or favourable financing
Users of any AMT Integrative and Managerial Systems (IMS)	*	*			*	
Systems, Devices and Stations (SDS)	*	*			*	◘
Intensity of use (AMT)	*	*			*	
Investment plans (Expctd)						*
Intensity and plans (AMT + Expctd)	*	*			*	
Integration $\left(\frac{IMS}{SDS}\right)$	*		◘	*		*

Key:

* - Positive significant impact
◘ - Negative significant impact

4.4.6 Strategic Motivations

Nine strategic motivations were considered as can be seen in question six of the survey instrument (see Appendix 1.0: Survey Instrument). Once again basic statistics are first analysis for this category of variables (see Table 55).

Increase in quality of products ranks highest followed by increased overall productivity and reduction in cost of finished products. The first two strategies are process improvement strategies while the last is a cost reduction strategy.

A test was first taken for independence of these different motivations. The null hypothesis is that there is no difference in the influence of strategic motivations in the firm's to adoption of AMT's with the alternate hypothesis being that the influence is different. The Kruskal-Wallis test or the H-test is used to test for independence (see Table 20).

Table 20: Test: Equality of strategic motivations' influence (Kruskal-Wallis test)

Strategy	Observations	Rank Sum
Increase in overall productivity	39	8779.00
Increase in flexibility of the manufacturing process	39	4012.00
Increase in quality of customer services	39	7032.00
Increase in quality of product(s)	39	8990.00
Increased domestic market share	39	6246.50
Increased foreign market share	39	6138.50
Reduction in cost of finished product(s)	39	8712.50
Reduction in labour costs	39	6698.50
Superior image of firm	39	5167.00

chi-squared = 58.726 with 8 d.f.
probability = 0.0001

chi-squared with ties = 61.680 with 8 d.f.
probability = 0.0001

The results show there is a significant difference in the influence of strategic motivations to AMT penetration in industry. The question to be addressed is whether they positively or negatively have an impact on AMT adoption; in what form and to what extent. Thus the following analysis proceeds.

4.4.7 Influence of Strategic Motivations on AMT adoption

The fourth hypothesis sought to find out whether there is a relationship between production strategies and the degree of automation in firms.

The following multiple regression model is used to test hypothesis 4:

$$\text{AMT}_i = \beta_0 + \beta_1(PRDCT)_i + \beta_2(LBCT)_i + \beta_3(PRD)_i + \beta_4(PRDQT)_i + \beta_5(CUSTSQ)_i + \beta_6(DMRT)_i + \beta_7(FMRT)_i + \beta_8(CPADV)_i + \beta_9(FLX)_i + \varepsilon_i$$

Equation 10

Where AMT_i = breadth of AMT adoption of firm i, $PRDCT_i$ = firm i's response to reduction in cost of finished goods, $LBCT_i$ = firm i's response to reduction in labour costs, PRD_i = firm i's response to increase in overall productivity, $PRDQT_i$ = firm i's response to increased quality of product(s), $CUSTSQ_i$ = firm i's response to increased quality of customers services, $DMRT_i$ = firm i's response to increased domestic market share, $FMRT_i$ = firm i's response to increased foreign market share, $CPADV_i$ = firm i's response to superior firm image, FLX_i = firm i's response to increase in the flexibility of the manufacturing process. ε_i is the error term.

4.4.7.1 Role of strategic motivations on users of AMT's

Logistic regression is used to test whether the level of influence of strategic motivations has any effect on firms' applying any form of AMT.

None of the strategic motivations are significant (see Table 74). It can therefore be comfortably concluded that strategic motivations of firms do not have any bearing on whether they use advanced manufacturing technologies or not.

4.4.7.2 Role of strategic motivations on IMS

Due to the inappropriateness of Poisson regression, negative binomial regression was used. Visual inspection of ims further shows negative binomial regression techniques may be more appropriate (see Figure 4)

The likelihood-ratio test of the over-dispersion parameter alpha is statistically significant (prob >= $chibar^2$ = 0.004), which suggests that Poisson regression is an inappropriate model (see Table 75).

This model as a whole is not statistically significant Prob > χ^2 = 0.1761. The variation in ims is only explained 6.7% of the time by strategic motivations and with no significant variables except for superior image of the firm.

Therefore the null hypothesis that strategic motivations have no effect on the use of integrative and managerial systems is rejected.

4.4.7.3 Role of strategic motivations on SDS

Poisson regression is used to test the effect of strategic motivations on usage of systems, devices and stations in firms (see Table 76).

Though the variation in SDS is explained 23% of the time by the strategic motivations the model does not fit well with the Poisson distribution. The chi-squared test using negative binomial regression is not statistically significant (Prob > χ^2 = 0.085) as compared to the Poisson regression (Prob > χ^2 = 0.0006). The significant strategic motivation variables were superior firm image and reduction in labour costs.

4.4.7.4 Role of strategic motivations on AMT

Negative binomial regression is used to model strategic motivations on AMT because the Poisson model had a very poor fit with this dataset. This situation is further verified visually (see Figure 8).

The model as a whole is weak with all of the variables insignificant save for superior firm image (see Table 77). The variation in the dependent variable is only explained about 6% by strategic motivations. The likelihood-ratio test of the over-dispersion parameter alpha is statistically significant (prob >= $chibar^2$ = 0.000), which suggests that Poisson regression is not an appropriate model. The null hypothesis is however rejected and it can be concluded that strategic motivations have some effect on the penetration of advanced manufacturing technologies in firms.

4.4.7.5 Role of strategic motivations on future plans to invest in AMT's

The Poisson regression is used even though it fits the model poorly since the likelihood-ratio test of the over-dispersion parameter alpha is not statistically significant (prob >= $chibar^2$ = 0.053).

The model as a whole is a weak one with only reduction in labour costs having a significant impact on expctd with a negative coefficient (see Table 78). The *_hatsq* p-value is significant with the Poisson model indicating that it is not well specified since the squared predictions have some explanatory power ("Regression Diagnostics", n.d.). As a result the null hypothesis is rejected. It can therefore be concluded that there is a significant negative relationship between strategic motivations and plans for future investment in AMT's.

4.4.7.6 Role of strategic motivations on current and future investments

The likelihood-ratio test of the over-dispersion parameter alpha (prob >= $chibar^2$ = 0.000) is statistically significant using the negative binomial regression however prob>chi^2 being 0.1799 indicates a statistically insignificant model as a whole for this analysis. Therefore the Poisson model is used (see Table 79).

The Poisson model is quite weak the variance in breath being explained 14.9% of the time by the strategic motivations the null hypothesis is however rejected since superior firm image has a significant and positive relationship on current and future investment plans in AMT's while using both the Poisson and negative binomial regression analysis.

4.4.7.7 Role of strategic motivations on ratio of IMS to SDS

Quantile regression (70%) as earlier recommended is used for this analysis (see Table 13). The model is statistically significant with increased domestic market share impacting negatively on the integration of systems, devices and stations in firms. No variable had a positive impact on integration of system devices and stations in firms (see Table 80).

4.4.8 Summary of results of strategic motivations on AMT adoption

The tabulation in **Error! Reference source not found.** shows the summary of the results of regression of strategic motivations on AMT adoption. The categories of motivations within Ugandan firms that play a significant role positive or negative on different measures of technological activities are also presented (see Table 22). The implications of the statistical results and models presented in **Error! Reference source not found.** become apparent when one looks at them concurrently with their effect on the outcome variables as presented in Table 22. These thus, as presented in **Error! Reference source not found.**, form the production strategies that significantly affect adoption of AMTs.

4.4.9 Interaction effects between technical skills and Strategic Motivations on AMT adoption

The fifth hypothesis sought to find out whether there were any interaction effects between education levels and the production strategies implemented in firms with respect to their degrees of automation.

The predictors for technical skills and Production strategies were obtained by taking the aggregated total of technical skills and production strategies. The resulting values of these predictors are then subjected to regression diagnostics. The transformations that result in near-normal distribution for these variables are:

- Technical skills (*TS*) - cubic (TS^3)
- Production strategies (*PS*) - natural logarithm $\rightarrow ln(PS)$

Table 21: Summary of strategic motivations against dependant variables

Dependant variable	Pseudo-R^2	P-value gof	Significant variables	P-values	Coeff.	Null hypothesis	Model
User	100%	-	-	-	-	Accepted	Insignificant
Ims	6.66%	-	*CPADV*	0.049	0.571	Rejected	weak
$\ln(ims_i) = 0.006\times PRDCT_i + 0.152\times LBCT_i + 0.199\times PRD_i - 0.010\times PRDQT^2 - 0.475\times\sqrt{CUSTSQ} - 0.308\times\frac{1}{\sqrt{DMRT}} + .006\times FMRT^3 + 0.517\times\ln(CPADV) + 0.023\times FLX^2 + 0.203$							
Sds	22.92%	0.01%	*LBCT*	0.040	0.534	Rejected	Significant but Poor fit
			CPADV	0.003	1.781		
$\ln(sds_i) = 0.151\times PRDCT_i + 0.534\times LBCT_i + 0.236\times PRD_i + 0.011\times PRDQT^2 - 0.761\times\sqrt{CUSTSQ} + 0.492\times\frac{1}{\sqrt{DMRT}} - 0.004\times FMRT^3 + 1.781\times\ln(CPADV) + 0.025\times FLX^2 - 3.901$							
AMT	5.86%	-	*CPADV*	0.026	0.770	Rejected	Significant
$\ln(AMT_i) = 0.052\times PRDCT_i + 0.240\times LBCT_i + 0.253\times PRD_i - 0.005\times PRDQT^2 - 0.603\times\sqrt{CUSTSQ} - 0.320\times\frac{1}{\sqrt{DMRT}} + .005\times FMRT^3 + 0.770\times\ln(CPADV) + 0.026\times FLX^2 - 0.159$							
Expctd	13.63%	0.14%	*LBCT*	0.014	-0.377	Rejected	Significant but poor fit
$\ln(\exp ctd_i) = 0.116\times PRDCT_i - 0.377\times LBCT_i + 0.007\times PRD_i - 0.001\times PRDQT^2 - 0.803\times\sqrt{CUSTSQ} + 1.380\times\frac{1}{\sqrt{DMRT}} + .008\times FMRT^3 - 0.089\times\ln(CPADV) - 0.010\times FLX^2 + 1.133$							
Breadth	14.91%	0.00%	*CPADV*	0.009	0.592	Rejected	Significant but poor fit
$\ln(breadth_i) = 0.085\times PRDCT_i + 0.083\times LBCT_i + 0.158\times PRD_i - 0.011\times PRDQT^2 - 0.490\times\sqrt{CUSTSQ} + 0.244\times\frac{1}{\sqrt{DMRT}} + 0.004\times FMRT^3 + 0.593\times\ln(CPADV) + 0.016\times FLX^2 + 0.665$							
Ratio	33.35%	-	*DMRT*	0.036	-3.12	Rejected	Okay
$\sqrt{ratio}_i = 0.155\times PRDCT_i + 0.040\times LBCT_i - 0.054\times PRD_i - 0.078\times PRDQT^2 - 0.886\times\sqrt{CUSTSQ} - 3.121\times\frac{1}{\sqrt{DMRT}} + 0.012\times FMRT^3 - 0.897\times\ln(CPADV) + 0.035\times FLX^2 + 6.444$							

The following multiple regression model is used to test hypothesis 5:

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

Equation 11

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

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

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

Table 22: Production strategies that drive firms' adoption patterns

	Reduction in labour costs	Increased domestic market share	Competitive advantage
Users of any AMT			
Integrative and Managerial Systems (IMS)			*
Systems, Devices and Stations (SDS)	*		*
Intensity of use (AMT)			*
Investment plans (Expctd)	◘		
Intensity and plans (AMT + Expctd)			*
Integration $\left(\frac{IMS}{SDS}\right)$		◘	

Key

* - Significantly positive coefficients

◘ - Significantly negative coefficients

Regression methods used include logistic, Poisson, negative binomial and linear regression. The significant results are then tabulated (see Table 23).

There is clearly some interaction between technical skills of employees and production strategies used by the company for most of the dependent variables (see Table 23). A further test is taken to find out which of the variables of technical skills and significant variables of production strategies interact when regressed against the dependent variables (see **Error! Reference source not found.** & Table 22). The results for the moderated regression analysis with IMS's are presented in Table 24. The results for the other dependents are presented in Appendix 8.4 Results of interactions between technical skills and production strategies (see Table 82, Table 83 & Table 84).

Table 23: Significant Interactions between Technical Skills (*TS*) and Production Strategies (*PS*)

Dependent Variable	Significant p-values before interaction		Significant p-values with interaction			Hypothesis
	TS	PS	TS	PS	TS×PS	
Users of any AMT	0.011	-	-	-	-	accepted
Integrative and Managerial Systems (IMS)	0.000	0.008	-	-	0.001	rejected
Systems, Devices and Stations (SDS)	0.000	-	-	-	0.017	rejected
Intensity of use (AMT)	0.000	0.018	-	-	0.002	rejected
Investment plans (Expctd)	-	-	-	-	-	accepted
Intensity and plans (AMT + Expctd)	0.000	0.016	-	-	0.001	rejected
Integration $\left(\frac{IMS}{SDS}\right)$	-	-	0.000	0.010	0.000	rejected

4.4.10 Interaction effects between technical skills and Influence of Proponents on AMT adoption

The sixth hypothesis sought to find out whether there are any interaction effects between education levels and internal/external influences in firms with respect to their degrees of automation.

The predictors for technical skills and influences of proponents are obtained by taking their aggregated totals. The resulting values of these predictors are subjected to regression diagnostics. The transformations that result in near-normal distribution for these variables are:

- Technical skills (*TS*) - cubic (TS^3)
- Influences of proponents (*IP*) - natural logarithm $\rightarrow ln(IP)$

Table 24: Moderating roles of production strategies on employee skills (IMS)

Dependent variable: IMS	Full Model with interactions β		
Employee skills			
Clerical employees	3.48***		-2.49**
Secretaries	-6.65****		3.47***
Functional managers	4.76**	-4.86***	1.01*
Engineers	3.58***		
Blue collar workers	-2.86***		
Production strategies			
Labour Cost reduction			
Domestic Market			
Competitive advantage	0.50***	0.33*	-1.28*
Interaction factors	**Labour**	**Dom. Mrkt**	**Competitive Advantage**
Clerical employees	-0.94***		2.70***
Secretaries	1.99****		
Functional managers	-1.12*	10.31****	-2.32*
Engineers	-0.71**		
Blue collar workers	0.74**		
Psuedo R^2	39.4%****	39.8%	38.2%****
Goodness of fit	46.0%	51.7%	33.5%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

The following multiple regression model was used to test hypothesis 6:

$$\text{AMT}_{ijk} = \beta_0 + \beta_1 (IP)_{ij} + \beta_2 (TS)_{ik} + \beta_3 (IP)_{ij} \times (TS)_{ik} + \varepsilon_i$$

Equation 12

Where $(IP)_{ij}$= *effect of firm i with influence of proponents k*

$(TS)_{ik}$= *effect of firm i with dimension j of technical skills and*

$(IP)_{ij} \times (TS)_{ik}$= *Interaction effects between technical skills and influences of proponents.*

Regression methods used included logistic, Poisson, negative binomial and linear regression. The significant results are then tabulated (see Table 25).

There is clearly some interaction between technical skills of employees and influences of proponents for most of the dependent variables (see Table 25). A further test is taken to find out which of the variables of technical skills and significant variables of internal and external proponents (see Table 18), interact when regressed against the dependent variables. The results for the moderated regression analysis with IMS's are presented in

Table 26on page 96. The results for the other dependents are presented in Appendix 8.5 Results of interactions between technical skills and influences of proponents (see Table 85, Table 86 & Table 87).

Table 25: Significant Interactions between Technical Skills (*TS*) and Internal/external influences (*IP*)

Dependent Variable	Significant p-values before interaction		Significant p-values with interaction			Hypothesis
	TS	*IP*	*TS*	*IP*	*TS×IP*	
Users of any AMT	0.003	-	-	-	-	accepted
Integrative and Managerial Systems (IMS)	0.000	0.001	-	-	0.005	rejected
Systems, Devices and Stations (SDS)	0.000	-	-	-	0.023	rejected
Intensity of use (AMT)	0.000	0.009	-	-	0.003	rejected
Investment plans (Expctd)	-	-	-	-	-	accepted
Intensity and plans (AMT + Expctd)	0.000	0.010	-	-	0.002	rejected
Integration $\left(\frac{IMS}{SDS}\right)$	-	-	0.001	-	0.001	rejected

Lastly, un-hypothesised results of interaction effects between production strategies and influences are presented for the various dependents (see Table 88, Table 89 & Table 90) in Appendix 8.6 Results of interactions between influences of proponents and production strategies. The results for IMS technologies are presented in Table 27.

Table 26: Moderating roles of influences of proponents on employee skills (IMS)

Dependent variable: IMS			**Full Model with interactions β**		
Employee skills					
Clerical employees	2.13***		-1.39*		-1.37**
Secretaries			2.44***	1.3****	2.32****
Managers				1.84**	
Engineers		0.96*		0.69**	
Blue collar workers	1.95**	0.89***		0.63***	1.19***
Influences					
MD/CEO					
Engineering		0.04***	0.03**	0.04**	0.02**
Marketing					
Customers			-0.03**		
Environmental	0.04****	0.02***		0.12***	0.02****
Taxes					
Interaction factors	**ENG**	**MRKT**	**Cust**	**ENV**	**TAX**
Clerical employees	-0.12**		0.03*	0.05**	0.12***
Secretaries			0.05***	-1.1***	-0.16****
Managers					
Engineers			-0.01*		0.07**
Blue collar workers	-0.10*	-0.07*	-0.02**		-0.08****
Psuedo R^2	41%****	41%****	45%****	42%****	42%****
Goodness of fit	48.2%	50.3%	91.2%	56.7%	56.3%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

4.5 Nature and structure of firm

The third hypothesis sought to find out whether there is a relationship between the firm configuration and the degree of automation in Ugandan firms. The elements of configuration analysed are among others type of manufacturing activity, size, nationality of ownership, type of ownership, location and foreign market penetration.

The influences of the configuration of the firm on AMT adoption patterns are initially measured using the one way analysis of variance (ANOVA) model that takes the following form:

$$y_{ij} = \mu + \alpha_i + e_{ij}$$

$$H_0 : \mu_1 = \mu_2 = \ldots = \mu_k = 0$$

Equation 13

Where y_{ij} is the i^{th} firms depth of AMT penetration in the j^{th} category of configuration, μ is the mean and α_i is the effect due to the i^{th} firm.

Table 27: Moderating roles of production strategies on Influence of proponents (IMS)

Dependent variable: IMS	Full Model with interactions β		
Influences			
MD/CEO	0.04*		
Engineering			
Marketing			-0.14***
Customers		-0.02**	
Environmental			0.15****
Taxes			-0.12**
Production strategies			
Labour Cost reduction			-0.25**
Domestic Market			
Competitive advantage			-6.92***
Interaction factors	**Labour cost reduction**	**Domestic Market**	**Competitive advantage**
MD/CEO			0.05**
Engineering		0.25*	
Marketing			0.14***
Customers		0.03**	
Environmental		0.07*	-0.09***
Taxes			0.08**
Psuedo R^2	28.2%****	31.4%****	31.9%****
Goodness of fit	0.13%	0.93%	1.2%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

4.5.1 Role of manufacturing activity on AMT adoption patterns

The eight categories of activities into which firms were grouped are- Food processing, Bottling, Textile, Printing & carpentry, Chemical, Plastics, Ceramics and metal industries. Dummy variables are defined for the different categories of manufacturing activities and ANOVA is used to test the hypothesis. The Metal industrial sector is then used as baseline category for comparison in relation to other sectors. The results of these are tabulated in Table 28. Negative binomial regression methods are found to be most appropriate in all significant cases.

4.5.2 Effect of firm size on AMT adoption patterns

The parameter considered as a measure of the firm size was the number of employees. The regression model took the following form:

$$\text{dependent variable} = \beta \times \ln(\text{empno}) + \text{constant}$$

Equation 14

where β = coefficient and empno = number of employees in the firm.

The results are shown in Table 29.

Table 28: Significant AMT penetration incident rate ratios (irr) of manufacturing sectors relative to the metal industry

	ANOVA p-value	Food processing	Bottling	Textile	Chemical	Ceramics
Users of any AMT	0.9328					
Integrative and Managerial Systems (IMS)	0.0263		2.618182			
Systems, Devices and Stations (SDS)	0.0089		5.333333			
Intensity of use (AMT)	0.0099		3.287671			
Investment plans (Expctd)	0.1840					
Intensity and plans (AMT + Expctd)	0.0159	1.689474	2.526316			
Integration $\left(\frac{IMS}{SDS}\right)$	0.8602					

Table 29: Regression of AMT adoption measures on firm size

	Users of any AMT	Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)	Integration $\left(\frac{IMS}{SDS}\right)$
Prob > χ^2	0.0081	0.0013	0.0030	0.0007	0.6849	0.0005	0.5323
Pseudo R^2	0.19	0.05	0.06	0.05	-	0.05	-
P-value	0.019	0.001	0.003	0.001	-	0.000	-
Coefficient	0.81	0.32	0.47	0.41	-	0.32	-
Constant	-1.88	-0.22	-1.91	-0.33	-	0.35	-

4.5.3 Role of ownership type on AMT adoption patterns

The types of ownership's are sole proprietorship, private limited company, partnership and others. Dummy variables were defined for the different ownership types and ANOVA is used to test the hypothesis as tabulated in Table 30.

From Table 30 it is clear that type of ownership has no bearing on the various measures of technological penetration in Ugandan manufacturing firms. Therefore the null hypothesis is accepted for this case.

Table 30: Analysis of variance and covariance of ownership type and the dependent variables

	Users of any AMT	Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)	Integration $\left(\frac{IMS}{SDS}\right)$
ANOVA Prob > F	0.6815	0.1072	0.1554	0.1151	0.0572	0.1513	0.4567

4.5.4 Role of nationality of ownership on AMT adoption patterns

Companies were categorized into local and foreign owned companies. The null hypothesis states that measures of AMT penetration are independent of whether the firm is locally owned or foreign. The results are shown in Table 31. ANOVA is initially used to test the hypothesis. The locally owned industry is then used as a baseline category for comparison in relation to the foreign owned industry. Negative binomial regression methods are found to be most appropriate in all significant cases.

Nationality of ownership does not determine whether firms are implementing AMT's or not the same applies to SDS's, breadth of adoption and integration efforts (see Table 31). At a 95% confidence interval the results show that the proportion of software usage and intensity of use (AMT) among locally owned firms is less than that among foreign owned firms. On the other hand foreign owned firms are less likely to have plans for future investment in AMT's as compared to there locally owned counterparts (see Table 31).

Table 31: Significant AMT penetration incident rate ratios of nationality of ownership relative to the locally owned industry

	Users of any AMT	Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)	Integration $\left(\frac{IMS}{SDS}\right)$
ANOVA p-value	0.1000	0.0355	0.1046	0.0444	0.0244	0.2022	0.2967
Foreign owned companies		1.900383		2	.4444445		

4.5.5 Role of geographical location on AMT adoption patterns

Four geographical locations are tested namely: Central, south-western, western and eastern. The null hypothesis is that users of AMT's are independent of the geographical location of the firm. ANOVA is used to test the hypothesis as tabulated in Table 32.

Table 32: Analysis of variance and covariance of region and the dependent variables

	Users of any AMT	Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)	Integration $\left(\frac{IMS}{SDS}\right)$
ANOVA Prob > F	0.5735	0.2216	0.1947	0.1823	0.1932	0.1634	0.2736

From Table 32 it is clear that the geographical locations of firms are independent of all the various measures of technological penetration in Ugandan manufacturing firms. Therefore the null hypothesis is accepted for this case.

4.5.6 Role of target markets on AMT adoption patterns

Companies were categorized into firms that produce purely for export, those that produce for the local market and those that produce for both foreign and local markets. The null hypothesis is that measures of AMT penetration are independent of their target markets. Dummy variables were defined for the different categories and ANOVA is initially used to test the hypothesis. The baseline category used is the exclusively non-exporting firms. The results of significant incident rate ratios (irr's) are shown in Table 33.

Table 33: Significant AMT penetration incident rate ratios of exporting firms relative to the non-exporting firms

	ANOVA p-value	Exporting only	Foreign and domestic market
Users of any AMT	0.3246	-	-
Integrative and Managerial Systems (IMS)	0.0339	6.11	5.25
Systems, Devices and Stations (SDS)	0.1321	-	-
Intensity of use (AMT)	0.0482	8.47	7.75
Investment plans (Expctd)	0.1311	-	-
Intensity and plans (AMT + Expctd)	0.0084	8.67	7.48
Integration $\left(\frac{IMS}{SDS}\right)$	0.8361	-	-

Users of AMT's, SDS's, plans for investments and integration efforts are totally independent of Ugandan firms' target markets.

Table 34: Significant AMT penetration incident rate ratios of exclusively non-exporting firms and exporters

	ANOVA p-value	Exporters
Users of any AMT	0.1777	-
Integrative and Managerial Systems (IMS)	0.0110	5.48
Systems, Devices and Stations (SDS)	0.0433	-
Intensity of use (AMT)	0.0140	7.94
Investment plans (Expctd)	0.0847	-
Intensity and plans (AMT + Expctd)	0.0024	7.79
Integration $\left(\frac{IMS}{SDS}\right)$	0.8802	-

A second test is carried out this time categorising firms into exclusively non-exporting firms and those that have some exporting activity. The results of this analysis are displayed in Table 34.

Table 34 confirms the earlier finding of independence between target markets and users of AMT's, SDS's, expected investments and integration efforts of their SDS's.

4.6 Preferred types of Flexibility of firms on AMT Adoption

The flexibility measures considered as driving factors for firms' shifting towards adoption of AMTs were the following:

i) Product Flexibility (ability to introduced new products)
ii) Mix flexibility (ability to change the range of products)
iii) Volume flexibility (ability to change the level of aggregated output)
iv) Delivery Flexibility (ability to bring forward planned delivery dates)

Table 35: Significant flexibility strategies to AMT adoption patterns

Dependent Variable	Volume flexibility		Delivery Flexibility		Constant
	p-value	coeff	p-value	coeff	
Users of any AMT	-	-	-	-	-
Integrative and Managerial Systems (IMS)	-	-	-	-	-
Systems, Devices and Stations (SDS)	0.031	2.22	-	-	-
Intensity of use (AMT)	0.043	1.32	-	-	-
Investment plans (Expctd)	0.003	-1.59	0.038	-0.94	1.90
Intensity and plans (AMT + Expctd)	-	-	-	-	-
Integration $\left(\frac{IMS}{SDS}\right)$	-	-	-	-	-

Each firm was required to select the two most important measures they best focussed on of these. Negative binomial regression is used. Significant results are tabulated in Table 35.

4.6 Categories of Technical collaboration on AMT Adoption patterns

Table 36: Technical collaboration categories significantly affecting AMT adoption patterns

Dependent Variable	Local Firms		Foreign Firms		Higher Institutions of learning		Constant
	p-value	*Coeff*	*p-value*	*Coeff*	*p-value*	*Coeff*	
Users of any AMT	-	-	-	-	-	-	-
Integrative and Managerial Systems (IMS)	0.005	0.53	0.023	0.95	-	-	-
Systems, Devices and Stations (SDS)	-	-	0.013	1.31	-	-	-
Intensity of use (AMT)	-	-	0.002	1.01	-	-	-
Investment plans (Expctd)	-	-	-	-	-	-	-
Intensity and plans (AMT + Expctd)	-	-	0.000	0.96	0.039	0.43	0.69
Integration $\left(\frac{IMS}{SDS}\right)$	-	-	-	-	-	-	-

The Firms and institutions considered vital for companies shifting towards adoption of AMT's were the following:

i) Local Firms

ii) Foreign Firms

iii) Research Institutions

iv) Higher Institutions of learning

Analysis is by Poisson regression techniques. The results of the significant categories are displayed in Table 36.

Organisations that collaborate more with foreign firm’s measure better on their degrees of AMT adoption followed by local firms and higher institutions of learning (see Table 36).

4.7 Liabilities to AMT adoption

Any liability to AMT adoption is considered to be an impediment. Impediments are envisaged to pose considerable obstacles to AMT adoption. Therefore under this section impediments to firms’ abilities to absorb AMT’s are considered.

The factors considered and tested as impediments to AMT adoption and penetration are:

i) Lack Tax Incentives
ii) Lack of financing
iii) Foreign competition
iv) Competing imports
v) Poor technical support from suppliers
vi) Lack of in-house expertise
vii) Incompatible equipment
viii) Cost justification
ix) Labour Resistance
x) Lack of confidence in these technologies
xi) Unreliable Power supply
xii) Inconsistent Government Policy
xiii) Poor Water Supply

Logistic, Poisson, negative binomial and linear regression methods are used where appropriate. Table 37 shows the significantly relevant and irrelevant impediments to adoption patterns whereas Table 38 displays their trends in relation to adoption patterns. Irrelevant impediments are those found to actually boost rather than encumber the various measures of AMT penetrations under study.

Table 37: Significant relevant/irrelevant impediments to AMT adoption patterns with p-values

Dependent Variable	**Significant impediments**			**Significantly irrelevant impediments**			
	Impediment	***p-value***	***coeff***	***Impediment***	***p-value***	***coeff***	***constant***
Users of any AMT	-	-	-	-	-	-	-
Integrative and Managerial Systems (IMS)	Technical support	0.004	-0.69	Lack of confidence	0.006	0.52	1.03
Systems, Devices and Stations (SDS)	Technical support	0.009	-1.10	Labour Resistance	0.005	0.87	-
Intensity of use (AMT)	Technical support	0.003	-1.05	Lack of confidence	0.011	0.79	1.57
Investment plans (Expctd)	In-house expertise Cost justification	0.010 0.003	-1.42 -1.41	Competing imports Incompatible equipment Lack of confidence	0.006 0.019 0.006	1.50 1.18 1.27	-
Intensity and plans (AMT + Expctd)	Technical support	0.003	-0.89	Lack of confidence	0.003	0.77	2.06
Integration $\left(\frac{IMS}{SDS}\right)$	-	-	-	-	-	-	-

Table 38: Trends of relevant/irrelevant impediments to AMT adoption patterns

	Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)
Technical support	*	*	*		*
Lack of confidence	◘		◘	◘	◘
Labour Resistance		◘			
In-house expertise				*	
Cost justification				*	
Competing imports				◘	
Incompatible equipment				◘	

Key:

* - Significant impediments
◘ - Significantly irrelevant impediments

4.8 Effect of Machine shop facilities on AMT Adoption patterns

4.8.1 Existing machine tools on AMT penetration measures

The predictor variables - machine tools, are shown in Table 39 and Table 40, the former displaying the significant coefficients and the latter their bias. The predictor variables are subjected to regression diagnostics and the outcome transformations are displayed in Table 39. Poisson or negative binomial regression techniques are used.

Table 39: Significant coefficients of machine tools on AMT measures of penetration

		Transform	Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)
1	**Lathe**	$\left(1/\sqrt{x}\right)^{\frac{1}{2}}$				6.43	
2	**Milling**	$\sqrt{x}$		1.51		-0.46	
3	**Drilling**	$\sqrt{x}$					
4	**Boring**	$\sqrt{x}$					
5	**Shaping**	$\sqrt{x}$					
6	**Planing**	$\sqrt{x}$	-1.79			-3.67	
7	**Grinding**	$\sqrt{x}$				1.32	
8	**Slotting**		2.94			-13.66	2.34
9	**Hobbing**		-3.86	-17.46	-3.73	-4.05	-3.87
10	**Power saw**	$\sqrt{x}$		-1.15	-0.85		-0.74
11	**Punching Machine**	$\sqrt{x}$	-14.10	-17.12	-22.14	-18.08	-21.17
12	**Bending Machine**	$\sqrt{x}$	2.37	4.57		-56.58	2.83
13	**Rolling**	$\sqrt{x}$		1.16		-19.37	
14	**Guillotine**		16.56	11.37		126.71	
15	**Fly/Presses**	$\sqrt{x}$		1.28	0.97	-3.02	
16	**Profile Cutter**			-16.54		-17.02	
17	**Crankshaft Grinder**		-2.62	-19.91	-3.67		-3.20
18	**Crankshaft Reconditioner**			5.86		-23.76	
19	**Line Boring**						
20	**Cone rod bearing**						
21	**Cylinder Head grinder**						
22	**Thread Cutting**		-1.81			37.24	
23	**Others**	$\sqrt{x}$					

The implications of the statistical results presented in Table 39 become apparent when one looks at them in tandem with their effect on the outcome variables as presented in Table 40. These thus, as presented in Table 39, are the machine tools that significantly influence adoption of AMTs.

Table 40: Trends of signs of coefficients of machine tools on AMT adoption measures

		Integrative and Managerial Systems (IMS)	Systems, Devices and Stations (SDS)	Intensity of use (AMT)	Investment plans (Expctd)	Intensity and plans (AMT + Expctd)
1	Lathe				∗	
2	Milling		∗		◘	
3	Drilling					
4	Boring					
5	Shaping					
6	Planing	◘			◘	
7	Grinding				∗	
8	Slotting	∗			◘	∗
9	Hobbing	◘	◘	◘	◘	◘
10	Power saw		◘	◘		◘
11	Punching Machine	◘	◘	◘	◘	◘
12	Bending Machine	∗	∗		◘	∗
13	Rolling		∗		◘	
14	Guillotine	∗	∗		∗	
15	Fly/Presses		∗	∗	◘	
16	Profile Cutter		◘		◘	
17	Crankshaft Grinder	◘	◘	◘		◘
18	Crankshaft Reconditioner		∗		◘	
19	Line Boring					
20	Cone rod bearing					
21	Cylinder Head grinder					
22	Thread Cutting	◘			∗	

Key:

∗ - Significant and positive coefficients
◘ - Significant and negative coefficients

Note: Expctd produced a gof of 53.64% and Psuedo R^2 of 44.4% implying a good model

4.8.2 Manufacturing and/or assembly systems in machine shops

The production/assembly systems analysed and tested for use in machine shops are:

- One of a kind
- In batches
- In cells
- Discretely on a line
- Continuous flow

The predictor variables were subjected to regression diagnostics. No firm was found to be using cell production in their machine shop. However none of the four remaining systems are found to influence in a significant way the manner in which Ugandan firms are adopting AMT's.

4.8.3 Ability to provide external services

The ability to provide external services was measured by the percentage of jobs handled by their machine shops that are from external clients. Results from regression diagnostics obtained a transform of $x^{\frac{1}{4}}$ for this variable.

Ideally one would assume that firms that contract external jobs in their machine shops would tend to enhance the automation of their systems in order to better satisfy the needs of their customers. Table 41 displays the significant coefficients of this test the results are inconsistent with this assumption due to their negative coefficients.

Table 41: Significant coefficients of contract ability (x) on AMT measures of penetration

	Users of any AMT	**Integrative and Managerial Systems (IMS)**	**Systems, Devices and Stations (SDS)**	**Intensity of use (AMT)**	**Investment plans (Expctd)**	**Intensity and plans (AMT + Expctd)**
Contractual competence	-2.11**	-1.41****	-1.61**	-1.48****	-1.45**	-1.47****
Constant	2.20****	1.59****	0.78****	1.96****	0.48**	2.17****

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

4.8.4 Machine shop inadequacy

The degree to which the firm's machine shop is limited is measured by the percentage of jobs rejected both internally and from external clients. Results from regression diagnostics obtained a transform of $x^{\frac{1}{4}}$ for this variable. Machine shop limitations of whatever form did not influence firms' incentives towards AMT adoption patterns.

4.8.5 Reasons for machine shop inadequacy

The limitations considered to be important that were tested were:

i) Precision Requirement
ii) Job size
iii) Job scale
iv) Cost of job
v) Lack of Skills
vi) Lack of Machines
vii) Lack of raw materials
viii) Disinterest in the jobs
ix) Others

None of these machine shop limitations are found to significantly affect AMT adoption patterns among Ugandan firms'.

4.9 Validation of study results

This section presents the results of the exercise the study undertook to validate the results that have been presented. Pictorial and graphical results are both presented that compare the expert opinion to the study results.

4.9.1 Determinants of SDS penetration

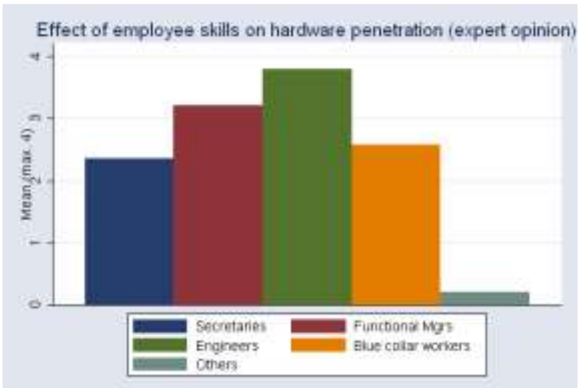

Figure 19: Employee skills versus hardware penetration

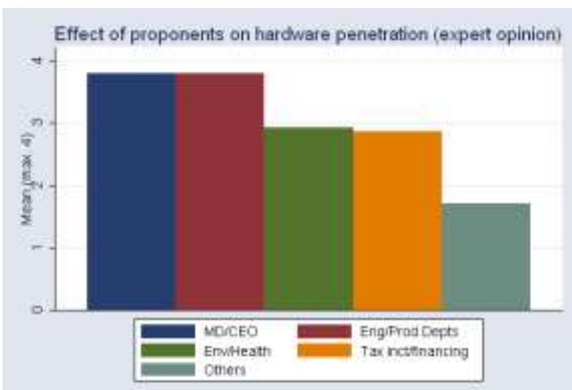

Figure 20: Influences versus hardware penetration

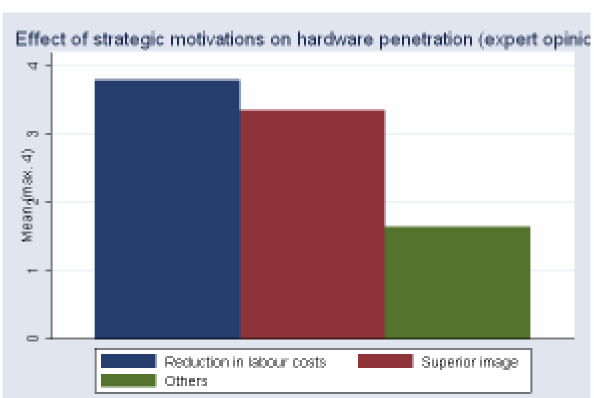

Figure 21: Strategic motivations versus hardware penetration

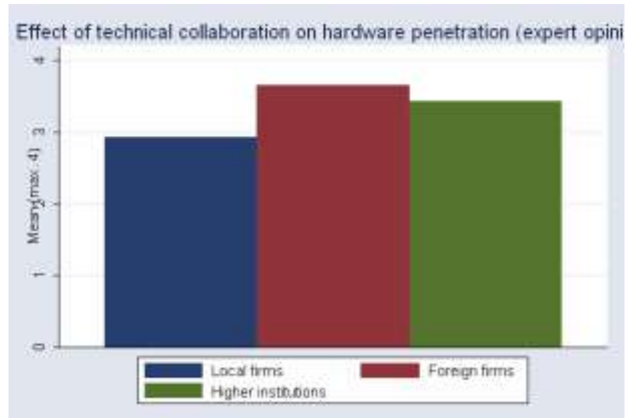

Figure 22: Technical collaboration versus hardware penetration

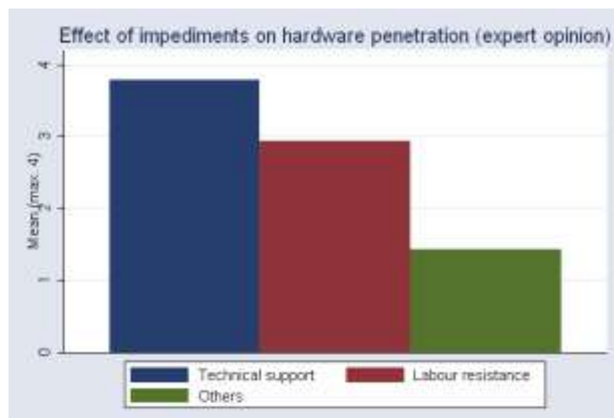

Figure 23: Impediments versus hardware penetration

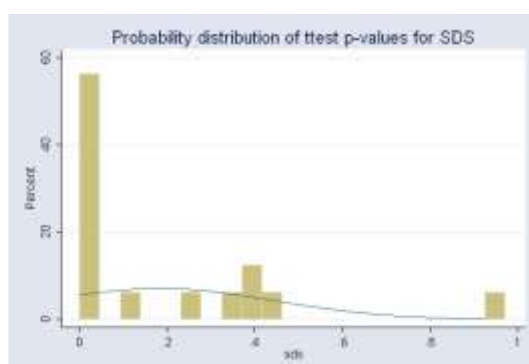

Figure 24: Distribution of validation tests for SDS

Table 42: Comparison between expert opinion and results of the study of the determinants to SDS penetration

	Actual Results β (p-value)	Null Hypothesised score	Expert Opinion (% mean)	ttest p-value	Comment
Employee Skills	$\ln(y_i) = \beta_0 + \beta_1 \times CE_i + \beta_2 \times SEC_i + \beta_3 \times MGR_i + \frac{\beta_4}{ENG^2} + \beta_5 \times BCW_i$				
Secretaries	1.34 (0.163)	≥ 2.5	59%	0.2429	Disagree
Functional Managers	2.87 (0.006)	≤ 3.0	80%	0.0947	Disagree
Engineers	-0.02 (0.001)	≤ 3.5	95%	0.0438	Agree
Blue collar workers	1.28 (0.000)	≤ 2.5	64%	0.4105	Disagree
Internal/External Influences	$\ln(ims_i) = \beta_o + \beta_1 \times MD^3{}_i + \beta_2 \times ENG_i^2 + \beta_3 \times MRT^2{}_i + \beta_4 \times CUST^3 + \beta_5 \times ENV^2 - \beta_6 \times TAX^2$				
MD/CEO	0.03 (0.046)	≤ 3.5	95%	0.0130	Strongly agree
Eng/prod departments	0.04 (0.028)	≤ 2.5	95%	0.0000	Strongly agree
Environmental/Health	0.04 (0.006)	≤ 2.5	73%	0.0234	Agree
Tax incentives/financing	-0.05 (0.003)	≥ 2.5	71%	0.9269	Strongly disagree
Production strategies	$\ln(ims_i) = \beta_2 \times LBCT_i + \beta_8 \times \ln(CPADV) + \beta_0$				
Reduction in labour costs	0.53 (0.040)	≤ 3.5	95%	0.0130	Strongly agree
Superior firm image	1.78 (0.003)	≤ 2.5	84%	0.0001	Strongly agree
Types of flexibility					
Volume flexibility	2.22 (0.031)	≤ 2.5	80%	0.0027	Agree
Technical collaboration					
Local firms	0.28 (0.564)	≥ 3.0	73%	0.3601	Disagree
Foreign firms	1.31 (0.013)	≤ 3.0	91%	0.0011	Agree
Higher institutions of learning	0.85 (0.51)	≥ 3.5	86%	0.3793	Disagree
Impediments					
Lack of technical support	-1.10 (0.009)	≤ 3.0	95%	0.0014	Strongly agree
Labour resistance	0.87 (0.005)	≥ 3.0	73%	0.4303	Disagree

4.9.2 Determinants of IMS penetration

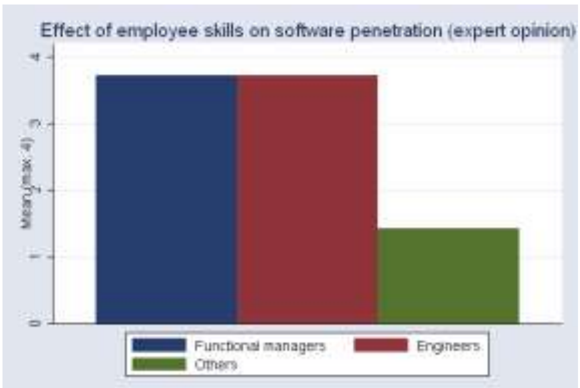

Figure 25: Employee skills versus software penetration

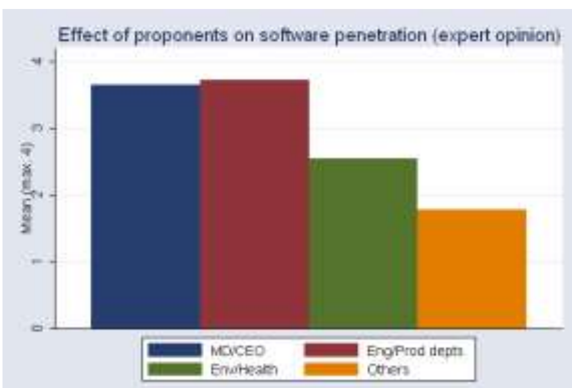

Figure 26: Influences versus software penetration

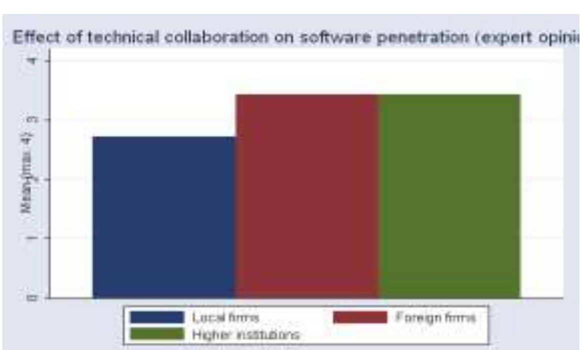

Figure 27: Technical collaboration versus software penetration

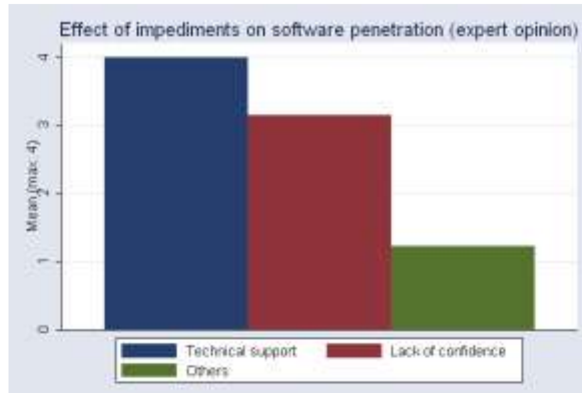

Figure 28: Impediments versus software penetration

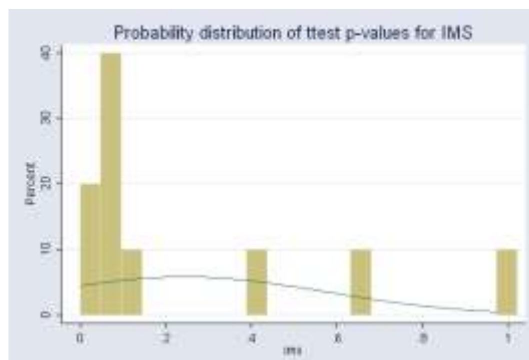

Figure 29: Distribution of validation tests for IMS

Table 43: Comparison between expert opinion and results of the study of the determinants to IMS penetration

	Actual Results β (p-value)	Null Hypothesised score	Expert Opinion (% mean)	ttest p-value	Comment
Employee Skills					
Functional Managers	0.974 (0.030)	≤ 3.5	93%	0.0555	Agree
Engineers	-0.007 (0.000)	≤ 3.5	93%	0.0555	Agree
Internal/External Influences					
MD/CEO	0.017 (0.000)	≤ 3.0	91%	0.0011	Strongly agree
Eng/prod departments	0.040 (0.016)	≤ 3.5	93%	0.0555	Agree
Environmental/Health	0.039 (0.000)	≤ 2.5	63%	0.4306	Disagree
Production strategies					
Superior firm image	0.571(0.049)	≤ 3.0	82%	0.0519	Agree
Technical collaboration					
Local firms	0.530 (0.005)	≤ 2.5	68%	0.1448	Disagree
Foreign firms	0.955 (0.023)	≤ 3.0	86%	0.0268	Strongly agree
Higher institutions of learning	0.340 (0.203)	≥ 3.0	86%	0.9732	Strongly disagree
Impediments					
Lack of technical support	-0.687 (0.0040	≤ 3.0	100%	-	Strongly agree
Lack of confidence	0.516 (0.006)	≥ 3.0	79%	0.6450	Disagree

4.9.3 Determinants to Integration efforts (ratio)

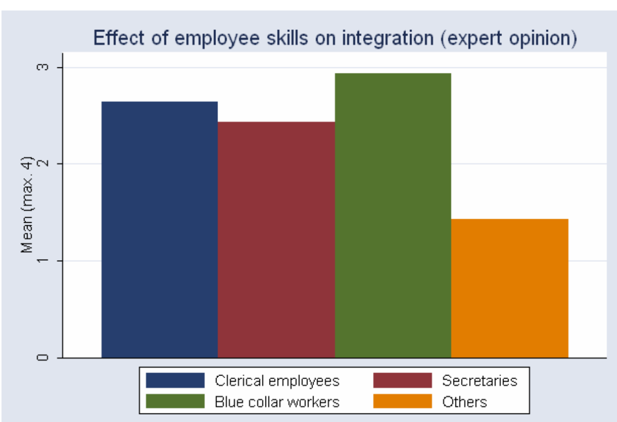

Figure 30: Employees skills versus integration efforts

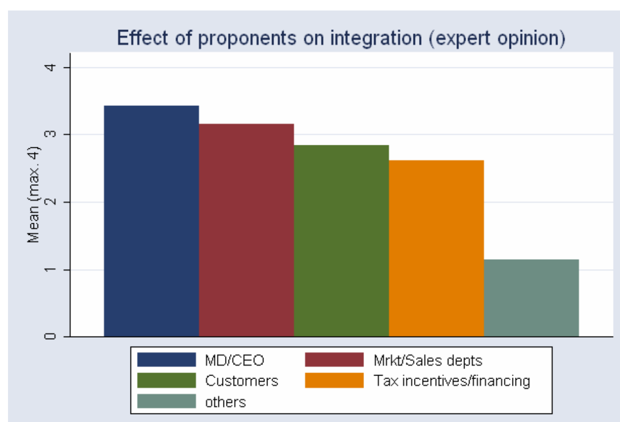

Figure 31: Influences versus integration efforts

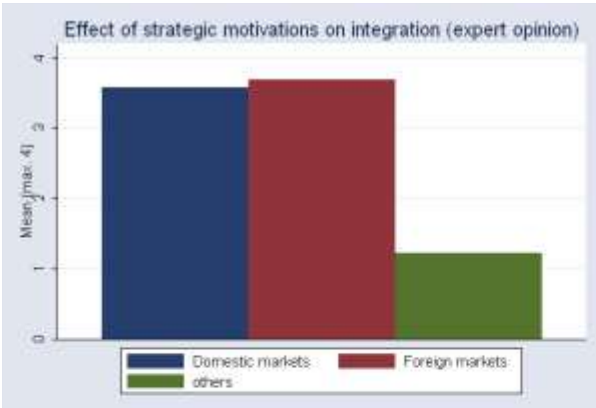

Figure 32: Strategic motivations versus integration efforts

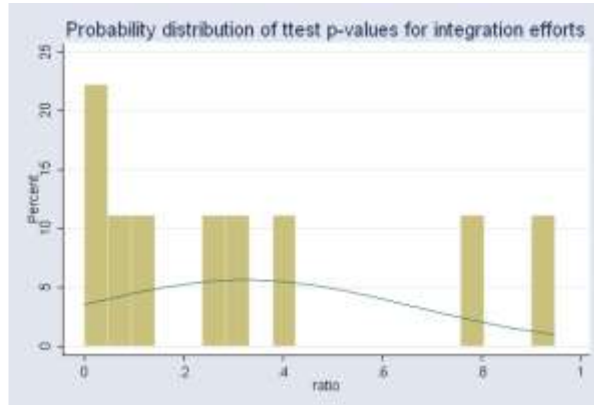

Figure 33: Distribution of validation tests for integration efforts

Table 44: Comparison between expert opinion and results of the study of the determinants to integration efforts

	Actual Results **β (p-value)**		**Expert Opinion** **(% mean)**		**Comment**
Employee Skills	$\sqrt{ratio}_i = \beta_0 + \beta_1 \times CE_i + \beta_2 \times SEC_i^2 + \beta_3 \times \sqrt{BCW_i}$				
Clerical employees	1.20 (0.001)	≤ 2.5	66%	0.2683	Disagree
Secretaries	-1.35 (0.000)	≥ 2.5	61%	0.3901	Disagree
Blue collar workers	-1.75 (0.000)	≥ 2.5	73%	0.9481	Strongly disagree
Internal/External Influences	$\sqrt{ratio}_i = \beta_0 + \beta_1 \times MD^3{}_i + \beta_2 \times MRT^2{}_i + \beta_3 \times CUST^3 + \beta_4 \times TAX^2$				
MD/CEO	0.02 (0.000)	≤ 3.0	86%	0.0268	Agree
Marketing/sales departments	-0.04 (0.032)	≥ 3.0	79%	0.7819	Agree
Customers	0.01 (0.042)	≤ 2.5	71%	0.1150	Disagree
Tax incentives/financing	0.06 (0.000)	≤ 2.5	65%	0.2990	Disagree
Production strategies	$\sqrt{ratio_i} = \beta_0 + \beta_1 \times \frac{1}{\sqrt{DMRT}} + \beta_2 \times FMRT^3$				
Increased domestic markets	-3.12 (0.036)	≤ 3.0	89%	0.0006	Strongly agree
Increased foreign markets	0.01 (0.136)	≤ 3.5	92%	0.0873	Agree

The foregoing graphs and tables are in agreement in the most part with the results of the study. Experts strongly agreed with the results concerning the factors affecting SDS and IMS penetration. At a 95% confidence interval, 58% of the results of the validation exercise are in agreement with results emanating from SDS analysis (see Figure 24 & Table 42). While, at a 90% confidence interval 60% of the results of the validation exercise are in agreement with those emanating from the IMS analysis (see Figure 28 & Table 43). However, the results concerning factors to integration showed a paltry 33% agreement with expert opinion (see Figure 33 & Table 44). The inter-sector performance results, which found the highest level of sophistication in the bottling and food processing industries, also largely concurred with expert opinion (see Figure 34).

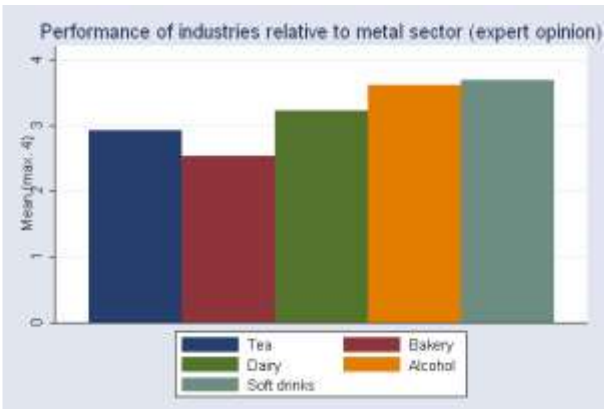

Figure 34: Industry performance

CHAPTER 5 DISCUSSION OF RESULTS

5.1 General Characteristics of the Ugandan Industry

In general the size of the firm based on its number of employees is a strong determinant to whether the firm uses any form of AMT's or not. Locally owned firms are significantly smaller in size than foreign owned ones. Firm size is also significantly and positively related to the measures of soft and hard technologies, intensity of use of AMT's and breadth of adoption in firms (see Table 29). These results are in conformity to studies by Lefebvre *et. al.*., (1996); Mechling *et. al., (1995)*, who found that firm size and AMT adoption are positively related and may impact on the ability of small firms to acquire AMT technology; and Schroder & Sohal (1999), who in addition to proving this postulate, also cited numerous studies that showed that firm size is positively related to the adoption of AMT.

There is no significant relationship between nationality of ownership of firms and whether they export or not. Thus both local and foreign owned firm's equally targeted foreign markets. However as expected, exporting firms were found to emphasise more on increased foreign market share as a strategic motivation compared to non-exporters (ttest p-value = 0.0110). There is no difference in the weight placed on increased domestic market share (p-value = 0.8366), by these two categories of firms. IMS's, intensity of usage and breadth of adoption patterns are significantly higher for firms that targeted export markets. These results conform to the findings of Mechling *et. al.* (1995).

Exporting firms are found to employ better trained staff than non-exporters (ttest p-value = 0.0068). In particular they tended to have better trained secretaries, functional managers and engineers (ttest p-values of 0.0459, 0.0003 and 0.0004 respectively). The aggregated skills levels of foreign owned companies are no different from their local counterparts. However foreign owned firms had better trained secretaries and functional managers (ttest p-values of 0.0439 and 0.0294 respectively).

Firms that targeted foreign markets succumbed more to internal/external influences than firms that don't export (p-value=0.0413). Exporting firms are much more strongly influenced by the

CEO/Managing Director and Marketing/sales department, (p-values = 0.0359, 0.0224 respectively), than non-exporters. There is no significant relationship between whether Ugandan firms are foreign owned and whether they exported their products (prtest p-value = 0.6426).

Foreign owned firms placed much more emphasis on production strategies (p-value = 0.0061) than their local counterparts while no significant difference existed between exporters and non-exports in their aggregated production strategies. Exporters emphasised reduction in product costs, increased productivity, increased foreign market share and competitive advantage (p-value = 0.0206, 0.0043, 0.0110 and 0.0326 respectively), as strategic as compared to the non-exporters. Increased foreign market share was the only variable considered more strategic among foreign owned firms (p-value = 0.0074).

The results suggest no difference in the skill levels of clerical employees, blue collar workers and Engineers in the foreign owned and local companies. However education levels are significantly higher for the functional managers and secretaries, (p =0.0294 and 0.0439 respectively), of foreign owned companies. Likewise exporting firms employ better trained staff than do those that don't export (ttest p-value=0.0068).

The results amongst Ugandan firms do not differ much from studies by Gerwin 1981, in relation to FMSs' champion; owner/managers' (Scott et. al., 1989); Top and senior manager's (Schroder & Sohal, 1999); CEO's (Lefebvre *et. al.*, 1996) in regard to their significant impact on AMT adoption trends. Yet again internal influences with the exception of marketing / sales departments had a stronger influence than external influences in AMT adoption just as was observed by Lefebvre *et. al. (1996)*. This was irrespective of the fact that Lefebvre *et. al. (1996)* considered customers, suppliers and consultants as their external influences whereas this study took customers, environment/safety issues and tax incentives/favourable financing as influences external to the firm.

In general the CEO/Managing Director had the strongest influence followed by environmental issues and then Engineering/production departments. Tax incentives and favourable financing were only considered important for further investment and integration of systems, devices and stations. The CEO/Managing Director was considered a more critical influence in foreign owned firms compared to their local counterparts (ttest p-value = 0.0064), whereas tax incentives and favourable financing are more emphasised among local firms (ttest p-value =0.0094). However, collectively foreign owned and/or exporting firms placed more emphasis on internal and external influences than their local and/or non-exporting counterparts (ttest p-value = 0.0167 and 0.0413 respectively).

5.2 Factors affecting users of AMT's

The principal users of computer-based technologies on a daily basis are the secretaries followed by the functional managers ($\bar{x}$ >70%). From the results in Table 15, employee skills had no significant effect on whether firms' use advanced manufacturing technologies or not. Strategic motivations are also found to have no impact on whether firms' use advanced manufacturing technologies or not (see **Error! Reference source not found.** & Table 74). On the basis of mean values, (see Table 54), the strongest influence is the CEO/MD ($\bar{x}$ = 4.7) followed by the engineering and production functions ($\bar{x}$ = 3.8). However, the results in Table 18 show that internal and external influences significantly affected firms' usage of AMT's when only the influences of the Managing Director and environmental issues were taken into consideration.

The nature or structure of firm's plays a modest role in whether Ugandan firms have adopted any form of advanced manufacturing technologies or not. The configuration of firms with respect to manufacturing activity, type and nationality of ownership, geographical location and target markets have no bearing on users of these technologies. However foreign owned firms are found to have a higher proportion of users of AMTs than locally owned ones [group proportional test (prtest), probability value (p-value) = 0.0476]. This may be partly attributed to capital accessibility, exposure and sophistication of the foreign investors. Lack of sophistication is further verified by the manner in which locally owned firms' were not keen in participating in this study and their general disinterest in the research findings (prtest p-value = 0.0258 for the response to whether they would like to receive results of the survey).

There is no significant difference between users of AMT's among exporting firms and exclusively non-exporting ones. However non-exporting firms were significantly disinterested in the outcomes of this study (prtest p-value= 0.0138).

There is a direct relationship between users of AMT’s and the firm size (see Table 29). As was expected locally owned firms are significantly smaller in size than their foreign counterparts [group mean comparison test (ttest), p-value = 0.0067].

5.3 Factors affecting penetration of integrative and managerial systems

At a 95% confidence interval it can be concluded that employee skills have a significant effect on the degree to which a firm uses integrative and managerial systems. The functional managers’ and engineers’ level of education are found to have significant impact on the penetration of these technologies (p-values of 0.014 and 0.003 respectively see Table 56). The Managing Director/CEO, engineering/production departments and environmental, safety or health concerns are found to influence significantly decisions about the degree of adoption of integrative and managerial systems in firms (p-values of 0.000, 0.016 and 0.000 respectively see Table 67), however the model in general was weak (Goodness-of-fit Prob > χ^2 = 0.24%).

Firms in the bottling industry were found to have invested about 2.6 times more in IMS’s than firms in the metal sector (see Table 28). In Table 29, the size of the firm is seen to be significantly and positively related to the level of IMS adoption. Schroder & Sohal (1999) showed that the nationality of ownership was independent of AMT adoption. However, this study shows that the proportion of software based usage of AMT’s among locally owned firms is less than that among foreign owned firms (ttest p-value = 0.0177). Foreign owned firms were found to place more emphasis on the integration technologies than the locally owned ones [ANOVA p-value = 0.0355; incident rate ratio (irr) = 1.9 see Table 31]. Exporting firms too are more likely to embrace these soft technologies (ttest p-value = 0.0055; irr = 5.48), compared to non-exporters (see Table 34).

On the other hand all aspects of strategic motivations save for the need to have a competitive advantage (p-value = 0.049), are found to have no effect on the use of integrative and managerial systems the model however was weak (see Table 75).

Companies that collaborated with foreign and local firms tended to have a higher level of adoption of integrative and managerial systems (see Table 36). This in part may be attributed to the weak or inexistent software piracy laws in Uganda which in turn enabled a conducive environment for collaboration of IMS's among firms both local and foreign. Worth noting, collaboration with local firms only exclusively helped the firm improve on its software capabilities.

Lack of technical support is the only deterrent that curtails efforts towards embracing IMS's in Ugandan firms (see Table 37). However, there is an apparent confidence in the Ugandan industry that the capabilities of IMS's can enable them achieve their business objectives.

5.4 Factors affecting adoption of systems, devices and stations

Employee skills are found to have a significant effect on the level of usage of systems, devices and stations in firms. In particular, the level of technical skills of the functional managers and blue collar workers (p-values of 0.017 and 0.000 respectively see Table 57), were found to have significantly positive impacts on the adoption of these technologies while clerical employees (p-value = 0.014), significantly impacted on SDS's negatively. The model fitted well with the Poisson distribution (Prob > χ^2 = 0.0000, Pseudo R^2 = 0.4497 and G.O.F = 55.17%). This result maybe attributed to the fact that blue collar workers by nature of their job description are more involved with the hardware components of AMT's and therefore tend to positively impact on the adoption of SDS related technologies. On the other hand clerical employees are more associated with the administrative functions of the firm and may therefore not clearly comprehend the production floor processes and equipment.

The Managing Director, engineering and production departments and environmental issues (p-values of 0.046, 0.028 and 0.006 respectively), are found to significantly influence positively the adoption of SDS's while Tax incentives/favourable financing (p-value = 0.003), influenced this variable negatively however, the model fitted poorly (see Table 68 on page 184).

At a 95% confidence interval no significant difference is found between the levels of investment in SDS's between foreign owned firms and those that are locally owned (ttest p-value < t = 0.0523).

Further analysis shows that whereas there is no difference between the SDSs' level of adoption in foreign owned firms vis-à-vis local ones, exporting firms have a significantly higher number of SDS's than non-exporters (ttest p-value = 0.0216).

Firms in the bottling industry are found to have invested about 5.3 times more in SDS's than firms in the metal sector (see Table 28). In Table 29, the size of the firm is seen to be significantly and positively related to the level of adoption of systems devices and stations.

Superior firm image and reduction in labour costs were found to significantly impact positively on firms' usage of SDS's (see Table 76). Akin to the findings of Lefebvre *et. al. (1996)*, labour cost reductions though significant were not of primary concern except in the adoption of system, devices and stations. The ability of firms to change the level of aggregated output (volume flexibility), significantly affected the level to which they had adopted systems devices and stations (see Table 35). The same can be said about companies that collaborate with foreign firms (see Table 36).

Once again lack of technical support was a deterrent to firms embracing systems, devices and stations (see Table 37). Surprisingly labour resistance posed no threat to firms embracing SDS's but rather seemed to promote their adoption. Probably one would conclude that labour laws are not adequate enough for a bold shift from labour intensive to automated production to pose a significant threat considering the lay-offs that this move would bring about. Therefore, the strategic production related benefits seem to outweigh the consequences of such a shift.

5.5 Factors affecting adoption of AMT's in general

The variation in intensity of use of AMT was explained 43% of the time by employee skills. Functional managers, engineers and blue collar workers are found once again to impact positively on the adoption of advanced manufacturing technologies in general (see Table 15 & Table 58) just as were the influences of the Managing Director/CEO, Engineering and production departments and environmental issues (see Table 18 & Table 69).

Firms in the bottling industry are found to have invested about 3.3 times more in both hard and soft forms of AMT's than firms in the other sectors (see Table 28). Once again locally owned entities were poorer investors in these combinational forms of AMT's (ttest p-value = 0.0222 and ANOVA p-value 0.0444 see Table 31). In Table 29, the size of the firm is seen to be significantly and positively related to the firm's intensity of use of AMT's. Exporting firms registered an irr = 7.94 compared to non-exporters in adoption of these technologies (see Table 34). The ttest analysis also showed that exporting firms had a higher proportion of AMT's than non-exporters (p-value = 0.0070).

Strategic motivations on the other hand are found to have little effect, through superior image of firms', on the penetration of advanced manufacturing technologies. On the other hand volume flexibility is the reason firms had already adopted AMT's - mainly their systems, devices and stations component of AMT's (see Table 35). Foreign firm collaboration partners once again tended to promote the intensity of usage of AMT's in companies (see Table 36).

Respondents demonstrated enough confidence in AMT technologies in general, however technical support is still lacking at this level of penetration (see Table 37).

Process improvement strategies and competitive advantage did not moderate technical skills in AMT adoption. Increased domestic market share however strongly moderated the way the technical skills of clerical employees, functional managers and engineers affect AMT adoption. There seemed to be confounding factors for the interaction effects between functional managers and the domestic market share strategy because the results show noticeable resistance from the former towards AMT adoption. Reduced labour cost on the other hand moderated the effects of secretaries and functional managers (see Table 83).

5.6 Factors affecting plans to invest in AMT's

Employees' skills are found to have no significant effect on firms' plans to invest in advanced manufacturing technologies (see Table 15 & Table 62). This probably would give the impression that in general most firms were satisfied with the status quo and therefore saw no need for further investment. Tax incentives and/or favourable financing are found to significantly influence this variable (see Table 18 & Table 70). Reduction in labour cost affected significantly plans to invest in AMT's (see **Error! Reference source not found.** & Table 78). Volume flexibility negatively affects firms' plans to invest in AMT's the same applies to delivery flexibility (see Table 35).

The nature, structure and/or configuration of firm's did not in many cases significantly affect this variable. All manufacturing sectors had similar plans for investments however this time round locally owned firm's had a stronger resolve to invest in these technologies in future (ttest p-value = 0.0122). This is corroborated by the earlier finding that there wasn't a significant difference between the levels of investment in SDS's between foreign owned firms and those that were locally owned (ttest p-value = 0.1046).

Schroder & Sohal, (1999) showed that the nationality of ownership was independent of AMT adoption. However, this study shows that locally owned firms demonstrated more willingness to embrace modern technologies than their foreign counterparts (ttest p-value = 0.0122) but seemed to lack the financial might. Financing local firms to invest in AMT's may not necessarily translate into successful implementation since the precise blend of skills, production and marketing strategies must be in place in order to triumph.

Among the internal and external influences, locally owned firms considered tax incentives/favourable financing a more critical factor compared to their foreign counterparts (ttest p-value = 0.0180). There is also a significant difference in the way these two types of firms considered cost justification as an impediment. Foreign owned firms considered cost justification significantly more of a deterrent to acquiring AMT's than the local ones (prtest p-value = 0.0476). This implies that the latter would be less hesitant in purchasing AMT's if they had the resources their foreign counterparts have at their disposal. Pros and cons of such a strategy could be contentious since the two categories of firms do not significantly differ in their levels' of innovativeness (p-value = 0.1353).

The foregoing discussion would drive one to the conclusion that foreign owned enterprises would rather have tax regimes on their products (short term strategy) than on the capital assets (or AMT's) they invest in (long term strategy). Based on the findings by Gerwin (1988), this would imply that, foreign owned firms are clearly not willing to commit themselves to long term capital investments. The study by Gerwin (1988) noted that “a strategic management with a short term policy orientation will attempt to avoid uncertainty by stressing a short run time horizon, financial control, and profit maximization in decision making”, while “a *long term policy orientation* will attempt to live with uncertainty by emphasizing a long run time horizon, adaptive planning, and minimizing the chances of disaster”. A plausible explanation for this trend in Ugandan firms would be that, foreign owned firms are unwilling to further invest in AMT technologies given their knowledge of the economic and political instabilities associated with developing countries.

Considering impediments, two deterrents to firms’ willingness to invest in AMT’s are evident (see Table 37). In-house expertise (which is closely related to technical support) and cost justification are disincentives while competing imports, incompatible equipment and confidence in these technologies are incentives to further investment.

5.7 Factors affecting current and future investments in AMT’s

Employee skills significantly impacted on both the intensity of use and plans for future investment in 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 (see Table 15 & Table 59)**.** The Managing Director/CEO, engineering and production departments and environmental issues positively influenced significantly this variable (see Table 18 & Table 71).

Both the food processing sector and bottling industrial sector tended to place more emphasis on current investments and future plans for investments in AMT’s with incidence rate ratios of 1.69 and 2.53 respectively compared to the metal sector (see Table 28). In Table 29, the size of the firm is seen to be significantly and positively related to this measure of penetration. Exporting firms too registered an irr = 7.79 compared to non-exporters with this variable (see Table 34). With a p-value of 0.0012 for the ttest it can be concluded with a 95% confidence interval that exporting firms score better than non-exporters on the breadth measure of penetration. However there is no significant difference between foreign owned and locally owned firm in this measure (ttest p-value=0.2022).

Only superior image of firms are found to have an impact on this variable among the strategic motivations analysed (see **Error! Reference source not found.** & Table 79). Collaboration with foreign firms and higher institutions of learning had a positive effect on the breadth of adoption of AMT's (see Table 36). Impediments to this measure comprised of lack of technical support as a deterrent and confidence in the technologies as an incentive (see Table 37).

5.8 Factors affecting the ratio of IMS to SDS

A high IMS:SDS ratio indicates that firms are integrating and therefore fully exploiting the capabilities of their SDS's. Employee skills are 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 is there to be integration whereas the higher the level of technical skills of secretaries and blue collar workers the less likely is there integration. Secretaries and blue collar workers impacted on the ratio variable negatively while clerical employees had a positive coefficient (see Table 15 & Table 60). This result validates the conclusion drawn above that clerical employees are more likely to affect IMS adoption as opposed to SDS adoption owing to the nature of their jobs i.e. being administratively based. Secretaries on the other hand are threatened by any effort towards integration possibly because they view it as a sign to replace them.

Among the internal and external influences, the Managing Director, marketing/sales department, customers and tax incentives/favourable financing were found to have significant effects on firms' integrating their SDS's with the marketing function negatively impacting on integration efforts (see Table 18 & Table 72). With respect to strategic motivations, only increased domestic market share had a significant albeit negative impact on the integration of systems, devices and stations in firms (see **Error! Reference source not found.** & Table 80).

There was no difference in the level of integration between the different manufacturing sectors. All sizes of firms were integrating at the same level (see Table 29). There was also no difference between the way exporting and non-exporting firms (ttest p-value= 0.8802), or foreign and locally owned firms (ttest p-value= 0.2967), were integrating their systems, devices and stations.

5.9 Moderating role of production strategies on technical skills

Venkatraman (1989) noted that "moderated regression analysis is a valid tool when variables measured on Likert scales are used", (as cited in Lefebvre et. al., 1996) . This situation applies to the case of variables measuring influences of proponents and strategic motivations but not for variables that measure technical skills.

Cost reduction strategies are found generally to moderate the technical skills. Reduction in labour costs, which is a cost reduction strategy, was found to strongly moderate the effects of technical skills of all categories of employees effectively changing their relationships. This strategy is found to deter the acquisition of IMS's in particular with the secretaries and blue collar workers who perceived it as a means to replace them (see Table 24). This result conforms to the findings by Lefebvre *et. al., (1996).* Increased domestic market share and competitive advantage, both customer-focussed strategies, moderated the way functional managers and clerical employees respectively perceived the adoption of IMS's.

Strategies perceived to reduce labour costs moderated the effects of secretaries and functional managers towards SDS adoption, the former changing form from a deterrent to a catalyst of SDS adoption. The effects of technical skills of clerical employees towards SDS's, are moderated by strategies that increased the domestic market share (see Table 82).

Any strategic attempt to adopt any form of AMT's moderated the resistance from the secretaries. Strategic motivations whether customer or cost reduction focussed moderated the relation with clerical employees, who are administratively based and therefore inclined more towards IMS technologies, when it came to the adoption of SDS's. By far the labour cost reduction strategy seemed to be the biggest moderating factor for employee skills amongst the strategic motivations (see Table 82 & Table 83).

The cost reduction strategy that sought to reduce labour costs also played a pivotal role in moderating the effect of technical skills on the way firms were integrating their systems, devices and stations. This strategy moderated the relation with engineers, blue collar workers and clerical employees (see Table 84). Blue collar workers who were strongly opposed to any integration efforts that were perceived to have an effect on their job security are moderated by this strategy. Increased domestic market share moderated the effect of technical skills of functional managers though the role seemed to be confounded while competitive advantage did not significantly moderate any effect towards integration.

5.10 Moderating role of internal and external influences on technical skills

Internal influences, in particular the engineering function, significantly moderated the effect of technical skills of clerical employees on IMS adoption (see Table 26). Tax incentives and favourable financing greatly moderated the way clerical employees, secretaries and blue collar workers considered IMS adoption. Environment issues on the other hand moderated the effect of secretaries.

Among the internal influences only the marketing function moderated the way employees considered SDSs' adoption. This function moderated the secretaries', functional managers' and engineers' effects on adoption of systems, devices and stations. External influences namely, customers and environmental issues, moderated the roles played by certain categories of employees towards SDS adoption. The former moderated the effect of blue collar workers while the latter moderated the effects of clerical employees, secretaries and blue collar workers (see Table 85).

Only external influences namely, the influence of customers, taxes and environmental issues moderated the effect of technical skills on the intensity of use of AMT's. By far environmental issues and tax incentives seemed to be the strongest moderating influences, affecting the clerical employees, secretaries and blue collar workers on intensity of use (see Table 86).

Internal influences are the strongest moderators of technical skills on the firms' integration efforts. The single strongest influence was that of the MD/CEO (see Table 87). The engineering function moderated the effect of the functional managers towards integration. The consistent negative effect of function managers seems to emanate from confounding factors and therefore is subject to further research for the Ugandan industries. Among the external influences only customers are seen to moderate the role played by secretaries towards integration.

5.11 Moderating role of internal and external influences on production strategies

This section discusses the results from an un-hypothesised test of interaction between production strategies and influences of proponents on the various measures of AMT adoption. Customer-focussed production strategies moderated the influence of proponents in relation to SDS adoption. The results show that these influences will positively moderate the factors to SDS adoption if the strategy involves increasing the domestic market share suggesting that firms are more likely to adopt SDS technologies if they are targeting foreign markets (see Table 88). Ugandan firms therefore do not seem to allot much importance to the domestic market. Strategies that sought to improve on the firm’s image moderated the influences of the marketing function, customers, environment issues and taxes with respect to SDS adoption.

On the other hand production strategies that are customer-focussed tended to moderate aspects of influences such as the marketing function, customers, environmental issues and taxes when it came to IMS adoption (see Table 27). The strongest moderating strategy on influences vis-à-vis IMS adoption was the need to maintain a superior image of the firm.

Customer-focussed production strategies moderated the influence of proponents in relation to intensity of use of AMT’s. These strategies moderated the influences of the engineering/production department and customers if the strategy involved increasing the domestic market share (see Table 89). Strategies that sought to improve on the firm’s competitive advantage once again moderated the influences of the marketing function, customers, environment issues and taxes with respect to AMT adoption. Accordingly, competitive advantage is not considered a basis for tax breaks or improved marketing for adopting AMT’s among Ugandan firms.

Production strategies focussed on reduction in labour costs moderated the effects of internal and external influences in the way firms were integrating their SDS technologies (see Table 90). The influences of the MD/CEO, marketing function, taxes and customers are all moderated when reduction in labour costs are taken into account. There is also notable interaction between the competitive advantage strategy and influences of proponents with the MD/CEO and customers being affected with regard to integration efforts.

5.12 Research Limitations

A number of limitations need to be considered while interpreting the results of this study. This research targeted manufacturing companies in Uganda that employ five or more personnel and have machine tools in their facilities.

Due to the large number of predictor variables used in this research, a lot of confounding factors sprung up. To start with it was necessary to limit interacting variables related to production strategies to only those that are significant during the preliminary regressions. These basically comprised of cost-reduction and customer-focussed strategies. This meant that the most important category of strategies namely, process-improvement, pertinent to AMT adoption was not analysed due to their insignificance initially. It was therefore difficult to explain why for example functional managers and the marketing function detested AMT adoption yet they should have been champions to this cause among Ugandan firms.

The size of the sample was relatively small for normal regression techniques to be reliable (n=39). This limited the analysis to non-parametric methods which are more accurate than OLS techniques given the sample size. In addition some sectors were not represented in the sample either due to their lack of sophistication or due to the lack of machine tools in the majority of these firms because of the limitations set out in the scope.

Only intangible assets were rigorously analysed as predictors to the firms AMT adoption measures. In the view of the author intangible aspects were more readily available given the resistance firms would have towards revealing their financial status which is the best measure of a firm’s tangible strength since such information is normally considered sensitive among Ugandan firms.

Lastly, this research took its sampling frame as the 2003 UBOS business register and therefore these results are only inferred to the population of firms that had registered with UBOS as of the year 2003. The current UBOS register is 2006/07 and implementing the same method, contains a sampling frame of about 3000 firms compared to the 1960 firms used in this study. However, this register is updated every five years and therefore a later register is expected to be released by the close of the year 2011

CHAPTER 6 CONCLUSIONS: SUMMARY AND RECOMMENDATIONS

6.1 Summary

This study analysed the machine tool driven industry in a developing country. It modelled the relationships between measures of Advanced Manufacturing Technologies' adoption trends and various sets of predictor variables. The bottling industry was found to be the most sophisticated in terms of the level of penetration of the various measures of AMT's. Firms in the bottling industry were found to have invested more in IMS's, SDS's and AMT's in general than those in the metal sector. Both the food processing sector and bottling industrial sector tended to place more emphasis on current investments and future plans for investments in AMT's compared to the metal sector.

Lack of technical support by far proves to be Ugandan firms' worst nightmare in the acquisition of AMT's. It single handedly affected the penetration of IMS's, SDS's, intensity of use and breadth of adoption. Other impediments included lack of in-house expertise, (which is closely related to technical support), and cost justification which are both deterrents to companies' plans for investment.

Respondents had confidence in IMS's, AMT's in general and breadth of adoption of AMT's. They were even confident enough to plan for future investments in these technologies. Labour resistance is not an issue when it came to the acquisition of SDS's while existence of competing imports only served to further encourage them to make the investment. The results indicate that firms strongly believed that they could source for AMT's quite compatible with their equipment. These results seem consistent since there isn't evidence of an impediment being a deterrent for one measure while transforming itself into a promoter of another measure (see Table 37).

Using Lefebvre *et.al.'s* words, any cost reduction strategy is "reactive or defensive" and often "counter productive" since new technologies are adopted with a view of replacing workers, rather than empowering them (1996). Justifiably reduction in labour costs and domestic market share played negative roles in some measures of AMT penetration namely future plans for investment and integration respectively.

Competitive advantage being a customer-focussed strategy, firms that embrace this strategy would already be competing at a high level as suggested by Lefebvre *et. al.* (1996). These authors noted that, customer focus is the "central tenet of total quality management" and such firms have often achieved a "high level of mastery of their production processes" . 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.

The foregoing results suggest that the most important users of computer based technologies are the functional managers, engineers and blue collar workers. The blue collar workers are extremely instrumental in the acquisition of SDS technologies but on the other hand together with the secretaries they play a significantly negative role in the firms' attempts to integrate the same technologies. This is in slight contrast to Lefebvre *et. al.* (1996), who found these two groups of employees to be most important due to their intense use of information technologies closely related to production operations. For the case of Uganda, whereas the secretaries rigorously used information technologies ($\bar{x}$ = 76.4%), blue collar workers were found to be mediocre users ($\bar{x}$ = 9.2%).

The empowering of clerical employees in the use of computer based technologies will have a positive impact on the integration of systems, devices and stations in firms. Worth noting is that the technical skills of functional managers and engineers in relation to computer based technologies had an insignificant impact on the integration of SDS technologies. Further, the engineers' skills play a minor role in the acquisition of SDS's. These results are in conformity with Lefebvre *et. al.* (1996) findings that; "the effect of white-collar workers is significant though far less important" than blue collar workers .

The two flexibility types that significantly affect the way firms adopt AMT's were their ability to change the level of aggregated output (volume flexibility) and their ability to bring forward planned delivery dates (delivery flexibility). Delivery flexibility is the main reason firms' intended to invest in these technologies in the near future. Thus, firms that already have SDS's have them as a result of the need for volume flexibility while firms that do not have SDS's but intend to invest in them are doing so primary to enhance their delivery flexibility capabilities.

By far collaboration with foreign firms is seen as very instrumental in enabling firms adopt most of the measures of technological penetration. Collaboration with foreign firms significantly impacted on adoption of IMS's, SDS's, intensity of use and the breadth of adoption of AMT's in Ugandan firms. Higher institutions of learning only enabled the firms intensify their use of AMT's as they plan for future investments.

Undoubtedly the results of this study provide interesting insights into the relatively atypical parameters that characterize the manufacturing industry in a developing country.

6.2 Conclusions

In conclusion this study discovered that the technical skills levels' of the blue collar workers, functional managers and engineers are very instrumental in implementing hardware forms of AMT's. On the other hand the skills of the clerical employees are seen to be quite instrument in integrating these technologies. This is a very important finding 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. It is no surprise therefore that the blue collar works were the marginal users of computer based technologies (9.23%) in Ugandan firms. These results are similar to the findings by Lefebvre *et. al.* (1996), where blue collar workers had a mean usage of 14.03%. 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 consider themselves part of the process of AMT adoption in the firm.

Another interesting revelation is that customers and marketing and sales departments have no influence on all of the dependant variables except for the fact that they are found to influence firms' integration efforts. This does not suggest that their influence is not really important but merely they are not exclusive preoccupations of Ugandan firms. This is a very strange realisation for firm's that are expected to compete globally. The CEO by far has the strongest influence closely followed by environmental issues then engineering and production departments. The means obtained for the influences of the CEO and production functions do not differ much from the findings by Lefebvre *et. al.,* (1996).

With regard to firm configuration, foreign owned firms showed more willingness to embrace advanced manufacturing technologies than their local counterparts. Locally owned firms are clearly limited by their financial capabilities. Foreign owned firm's preferred policies geared towards tax regimes that favour short term strategies – for example reduced taxes on their products. Locally owned firms on the other hand preferred policies that would enhance their AMT capacity i.e. long term strategies. As to whether financing local owned firms would translate into growth of the manufacturing industry is subject to debate. The size of the firm was proportional to its adoption of AMT's. The firms in the bottling industrial sector were the most sophisticated followed by those in the food processing sector. In general foreign owned and/or exporting firms performed better with regard to AMT adoption than their locally owned and/or non-exporting counterparts.

The strongest single strategic motivation that seems to drive Ugandan firms to invest in AMT's appears to be the superior image of the firm followed by reduction in labour costs. Whereas process improvement strategies ranked highest amongst Ugandan firms strategic priorities ($\bar{x} > 4$), regression analysis revealed they are not significant predictors to AMT adoption. Rather customer-focussed (competitive advantage and domestic market share), and cost reduction (labour costs), strategies played a more significant role in adoption trends. 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 only customer-focussed domestic market share, impeded integration efforts.

Gerwin (1988), noted the lack of understanding of radical new computer related manufacturing technologies and their implications as causing significant barriers to their diffusion. Likewise, in this study the variable used to measure firms' future plans for investment proved to be a weak one. This may be attributed to the fact that respondents do not recognise the use of most of the technologies since they have never been exposed to them in the first place. On the other hand it may be an indication of satisfaction in the status quo and therefore disinterest in further investment in AMT's. Nonetheless, one optimistic observation was that tax incentives and favourable financing significantly and positively influenced this variable. Further, cost justification is a deterrent only to foreign owned firms in relation to future plans for investment, implying that locally owned plants would willingly upgrade to AMT's given the financial resources.

It is evident that Ugandan firms are in their infancy with regard to AMT adoption. That is why there seems to be a clear trend of primarily cost reduction strategies moderating the way the predictor variables affect adoption. This is in agreement with Lefebvre *et. al. (1996),* 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.

The fact that volume flexibility impacted significantly on Ugandan firms' adoption patterns should not be a surprise since the alternative would be to resort to labour intensive production. This would require hiring extra labour when increased output is desired while laying off staff when sales slowdown an alternative which is of course less flexible than having for example, SDS technologies. The significance of volume flexibility thus verifies the earlier findings related to the emphasis placed on cost reduction strategies by Ugandan firms.

Ugandan firms that are found to collaborate with foreign firms scored best on most of the measures of AMT adoption. This was closely followed by those that partnered with local firms and higher institutions of learning. Collaboration with local firms resulted in higher IMS adoption while collaboration with higher institutions of learning resulted into higher breadth of adoption.

The most significant impediment to AMT adoption in Ugandan firms is the 'lack of technical support'. However, there is a significant amount of confidence among Ugandan firms in the benefits of advanced manufacturing technologies in general.

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. There is certainly a potentially rich area of research for policy makers, industry and academics.

6.3 Recommendations

The machine tool driven manufacturing industry in Uganda has been shown in this study to portray unique characteristics. The models presented unravel numerous characteristics atypical to this industry that are most likely applicable to any developing country. A number of recommendations from this study for the three categories of stakeholders are identified. The stake holders are Government, industry and researchers.

6.3.1 Recommendations for Government

- Firm size measured by the number of employees was found to be a strong and positive determinant of AMT adoption. However annual sales would have performed better as a measure of firm size. The problem lies in the approach in which such information sensitive to firms can be obtained. Government involvement may be crucial if sensitive data is to be extracted from industry for more reliable models.
- There is a need for policy implementers to design policies that facilitate the building of local and specialised technical expertise in AMT technologies. In that way 'lack of technical support' would cease to be a significant impediment to adoption of AMT's.
- Government should strengthen and enforce conducive labour laws such that employees are confident about their job security and so present less resistance to any attempts to embrace AMT's.
- Policy formulation into setting international standards for the domestic consumers is required in order to encourage firms that do not export to adopt AMT's.
- Whereas government can afford to remain silent on the weak software piracy laws in Ugandan since they encourage collaboration among local firms thus enhancing IMS adoption, it must strengthen intellectual property rights (IPR) laws to encourage innovation in industry.
- Since volume flexibility significantly dictates AMT particularly SDS adoption, Government can create policies that regulate the market in a way that encourages volume flexibility by intervening in the demand and supply chain depending on the sector. This would force firms to adopt AMT technologies especially SDS's due to their flexibility benefit.

- Government should make a strategic choice between tax policies that support long term objectives that favour locally owned firms and policies that support short term strategies that favour foreign owned firms. This study showed that locally owned firms are more interested in enhancing their AMT capacity (long term), while foreign owned firms would prefer tax regimes on their products (short term).
- Government should set an environment for more favourable financing as well as tax incentives especially among locally owned companies vis-à-vis foreign investors to enhance the formers ability to embrace AMT's and compete better.
- Government should consider setting incentives for firms that collaborate with foreign firms and higher institutions of learning since there is evidence that these categories of firms measure better on AMT adoption trends.

6.3.2 Recommendations for industry

- Training of blue collar workers in computer based technologies or improving their technical skills is necessary since they are instrumental to the adoption of SDS's in particular and AMT's in general. This will make them not feel isolated from the process of AMT adoption.
- Proper orientation of clerical employees with production floor technologies and blue collar workers with administrative based processes is recommended.
- The strong interaction shown by the marketing function in adoption of SDS's coupled with the fact that this function negatively impacted on integration efforts, means that there is a need for firms to strengthen the influence of this function for improved AMT adoption of hardware components.
- The evolutionary pattern proposed by Lefebvre *et. al. (1996),* of moving from primarily cost related considerations in the earlier phases of automation to the inclusion of other strategic considerations of a less financial nature in the later stages can be adopted by Ugandan firms.
- Need for industry to consider domestic markets as being as important as foreign markets in order not to lose out to foreign companies in the domestic arena – 'charity begins at home'.
- There is a need for industry to improve on the emphasis they currently place on process improvement strategies since at the moment they do not seem to affect AMT adoption trends as compared to cost reduction and customer focused strategies.

6.3.3 Recommendations for Further Research

- Future research could focus on extracting data related to annual sales as a measure of firm size and using it as a control variable in the full regression models with interactions.
- More research is needed to uncover confounding factors which are evident with functional managers who showed significant levels of threat.
- Research is needed to find out whether financing locally owned and/or non-exporting firms would translate into real growth of the manufacturing industry in relation to AMT adoption.
- Some of the measures like breadth of adoption and plans for adoption seem weak in measuring adoption trends. Future research could consider looking at a longitudinal study approach to better unravel the relationships.
- The cumulative count of the various forms of AMT's does not capture the degree of radicalness depending on the manufacturing sector. Future research in how to best measure this aspect is recommended.
- There is need to do research with many respondents per firm such that more objective opinions are obtained within the firm.
- Future research must consider increasing the sample size so that ordinary linear regression techniques can be applied.
- The sampling frame used for future research should be extracted from a more current UBOS business register.
- Research institutions should become more relevant to industry since currently they do not have a significant impact on industry in terms of collaboration with relation to any form of AMT adoption.

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APPENDICES

Appendix 1.0: Survey Instrument

Part A

1. **Please *circle* the abbreviation of any of the following technologies which you have already installed in your plant or have already placed on order for your plant.**

CAD/E	Computer aided design/engineering	**PPIC**	Production planning/inventory control
CAPP	Computer aided process planning	**LAN**	Local area networks management software
CAT	Computer aided testing/inspection	**WAN**	Wide area networks management software
SPC	Statistical process control	**GT**	Group technology
CAM	Computer aided manufacturing	**EDM**	Engineering data management
MRP	Materials requirements planning		
MRPII	Manufacturing requirements planning	**Others** (list below)	

2. **Please enter, in the spaces provided, the number of each of the following programmable systems, devices, stations, etc. which you already have in your plant.**

AID	Automated identification stations	______
AIN	Automated inspection station	______
AMHD	Automated material handling devices	______
CAD	Computer aided design workstations	______
CNC	Computerized numerical control machine tools	______
NC	Numerical control machine tools	______
PLC	Programmable controllers	______
RBT	Robots	______
SPCS	Shop-floor control systems	______

Others (specify below)

3. Do you have plans in place to adopt or expand your use of any of the following technologies? Please circle the appropriate abbreviation(s).

CAD/E *SPC* PPIC *EDM* CAPP *CAM* LAN *GT* AID *AIN* AHMD *CAD* CNC *NC* PLC *RBT* SFCS

4. Please enter, in the spaces provided, the percentage (or ratio e.g. $\frac{3}{14}$) of employees within each of the categories below that use computer-based technologies on a daily basis.

Clerical employees ________

Secretaries ________

Functional Managers ________

Engineers ________

Blue collar workers ________

5. On a scale of 1-5 indicate how the following groups, individuals or factors influence decisions to adopt AMT's in your firm.

	Very low <u>influence</u>				Very high <u>influence</u>
Managing Director (MD)/CEO	1	2	3	4	5
Engineering / Production departments	1	2	3	4	5
Marketing / Sales departments	1	2	3	4	5
Customers	1	2	3	4	5
Environmental, safety, or health	1	2	3	4	5
Tax incentives and/or favourable financing	1	2	3	4	5
Others (specify and give a rating below)					

6. On a scale of 1-5 indicate how the following strategic motivations would influence or influenced your decision to adopt AMT's

	Very low <u>influence</u>				Very high <u>influence</u>
Reduction in cost of finished product(s)	1	2	3	4	5
Reduction in labour costs	1	2	3	4	5
Increase in overall productivity	1	2	3	4	5
Increase in quality of product(s)	1	2	3	4	5
Increase in quality of customer services	1	2	3	4	5
Increased domestic market share	1	2	3	4	5
Increased foreign market share	1	2	3	4	5
Superior image of the firm	1	2	3	4	5
Increase in the flexibility of the manufacturing process	1	2	3	4	5
Others (specify and give a rating below)					

7. Please tick those factors listed below which most impeded or prevented altogether your implementation or investment in any of the technologies listed in parts 1 and 2.

______ Inadequate tax incentives

______ Lack of favorable financing

______ Competition from foreign investors

______ Protection from competing imports

______ Lack of technical support/documentation from vendors

______ Insufficient in-house expertise

______ Equipment incompatible with existing plant layout/work flow

______ Insufficient cost justification

______ Management/labor resistance or union work rules

______ Lack of confidence in these technologies

______ Other (specify)

8. What per cent of each of these strategies do you employ with respect to flexibility of production? (parts a through c should sum to 100%):

a. Reactive (imposed by needs of market) __________

b. Proactive (imposed by anticipated intentions of business) __________

c. Others (specify) __________

9. Please tick two (2) most significant types of flexibility your firm best focuses on

- Product flexibility (ability to introduce new products)
- Mix flexibility (ability to change the range of products)
- Volume flexibility (ability to change the level of aggregated output)
- Delivery flexibility (ability to bring forward planned delivery dates)

10. On a scale of 1-5 indicate how open your firm is to risk taking and discovery

Risks not encouraged				**Discovery encouraged**
1	2	3	4	5

11. From the list below *tick* the categories of firms and institutions your organisation has technical collaboration with:

- Indigenous (local) firms
- Foreign firms
- Research Institutions
- Higher institutions of learning

Part B (To be filled by firms that have machine tools)

1. **Please tick any of the following machine tools which you have already installed in your plant (indicate the number of each in the spaces provided):**

Lathe machines _________#
ĭ Milling machines _________#
ĭ Drilling machines _________#
ĭ Boring machine _________#
ĭ Shaping machines _________#
ĭ Planing machines _________#
ĭ Grinding machine _________#
ĭ Others (specify below)

2. What per cent of jobs by your machine shop involve the manufacture and/or assembly of parts and/or products? (parts a through e should sum to 100%):

a. as one-of-a-kind ______%

b. in batches ______%

c. in cells ______%

d. discretely on a line ______%

e. as a continuous flow ______%

3. **What percent of all jobs handled by your machine shops are from clients outside the firm (external sources)?** ______%

4. What percent of jobs received cannot be handled by your machine shop? _________

5. Please *tick* the main reasons for rejection of job orders in 4 above:

ĭ Precision Requirements
ĭ Capacity Restrictions (Size of the job)
ĭ Capacity Restrictions (Scale of the job)
ĭ Cost of the job
ĭ Lack of skilled labour
ĭ Others (Specify)

Would you like to receive a copy of the executive summary of this survey?___ Yes ___ No

Appendix 2.0: Firm configuration

ID No.	No. of employees	Ownership type	Foreign or Locally owner	Exporter?	District	Region	Manufacturing strata
1	100	P	F	N	Mbale	E	3
2	10	P	F	B	Mbale	E	3
3	8	P	L	N	Soroti	E	8
4	25	P	F	B	Soroti	E	8
5	7	P	L	B	Mbale	E	8
6	80	P	F	N	Mbale	E	5
7	303	P	F	B	Jinja	E	8
8	83	O	L	B	Mbale	E	1
9	103	S	F	B	Jinja	E	8
10	80	P	F	Y	Kasese	W	8
11	6	S	L	N	Masaka	C	8
12	540	O	L	Y	Kanungu	S	1
13	220	O	F	Y	Bushenyi	S	1
14	60	P	L	B	Mbarara	S	8
15	1162	P	F	B	Masindi	W	1
16	20	S	F	B	Kasese	W	3
17	332	P	F	B	Kasese	W	7
18	64	P	L	B	Kampala	C	8
19	51	P	F	N	Kampala	C	8
20	84	P	F	B	Kampala	C	8
21	249	P	F	B	Kampala	C	8
22	82	P	F	B	Kampala	C	8
23	20	P	L	B	Mbarara	S	8
24	648	P	F	Y	Kibaale	W	1
25	225	P	F	Y	Kyenjojo	W	1
26	27	P	F	Y	Bushenyi	S	1

27	127	P	F	Y	Kyenjojo	W	1
28	270	P	F	B	Kampala	C	8
29	9	P	L	B	Kampala	C	8
30	198	P	L	B	Kampala	C	8
31	3044	P	F	Y	Kabarole	W	1
32	127	P	L	Y	Kabarole	W	1
33	282	P	F	B	Kampala	C	2
34	200	P	F	B	Jinja	E	1
35	350	O	L	B	Luweero	C	8
36	612	P	F	B	Mukono	C	2
37	488	P	F	B	Mukono	C	3
38	135	P	F	B	Mbarara	S	2
39	3401	P	F	B	Jinja	E	1

Appendix 3.0: Integrative and Managerial Systems

ID No.	CAD/E	CAPP	CAT	SPC	CAM	MRP	MRPII	PPIC	LAN	WAN	GT	EDM	Others
1								1					
2													
3													
4	1					1	1	1	1				
5													
6								1					
7									1				
8			1		1			1					
9		1			1		1	1					
10	1	1	1	1		1	1	1	1			1	1
11													
12			1	1				1	1				
13			1	1				1	1				
14								1	1				
15	1		1	1				1	1	1		1	
16								1					
17	1	1				1	1	1	1	1		1	
18	1		1		1			1	1				
19						1		1					
20								1	1				
21	1	1		1		1	1	1	1				
22				1		1		1	1				
23								1	1				
24	1	1		1			1	1	1	1		1	
25													
26	1			1				1	1	1			
27	1	1		1				1	1	1		1	
28					1	1		1	1				
29													

30	1		1		1			1	1				
31													
32	1					1		1	1	1			1
33		1		1		1		1	1	1		1	
34					1	1		1	1	1		1	1
35	1			1									
36		1	1		1	1	1	1	1	1	1	1	
37	1		1		1	1		1	1	1			
38	1		1		1	1		1	1	1			
39	1			1				1	1	1			

Appendix 3.1: Systems, Devices and Stations

ID No.	AID	AIN	AMHD	CAD	CNC	NC	PLC	RBT	SPCS	CAM	Semi automated m/cs
1											
2											
3											
4				1							
5											
6											
7											
8											
9											
10			1	1			1		1		
11											
12											
13											
14											
15	1	1		1	1		1		1		
16											
17				1			1		1		
18		1	1	1			1				
19											
20											
21				1							
22							1				
23											
24		1		1	1		1				
25											
26				1			1	1			1
27				1	1		1				

28							1			1
29										
30		1	1				1			
31										
32				1			1			
33	1	1	1		1	1			1	
34	1						1			
35				1		1				
36	1	1	1				1	1	1	
37		1	1				1	1		
38		1	1				1	1		
39		1	1	1			1		1	

Appendix 3.2: Future Acquisitions

ID No.	CAD/E	CAPP	CAT	SPC	CAM	MRP	MRPII	PPIC	LAN	WAN	GT
1											
2									1		
3											
4											
5											
6									1		
7											
8									1	1	
9									1		
10											
11											
12						1	1	1		1	
13						1	1	1		1	
14						1	1				
15		1									
16											
17											
18	1								1	1	
19											
20								1			
21											
22											
23						1	1				
24											
25											
26					1						
27											
28		1		1							
29								1			

30	1								1	1	
31											
32											
33											
34	1	1		1				1			
35					1						
36											
37											
38											
39											

ID No.	EDM	AID	AIN	AMHD	CAD	CNC	NC	PLC	RBT	SPCS	Others
1											
2								1			
3											
4											
5											
6											
7											
8											
9											
10											
11											
12											
13											
14				1							
15											
16											
17											

18								1			
19											
20											
21											
22											
23				1							
24											
25			1					1			
26											
27				1	1					1	
28											
29	1										
30								1			
31			1					1			
32											1
33											
34	1										
35						1					
36											
37											
38											
39											

Appendix 4.0: Technical Skills

ID No.	Clerical employees	Secretaries	Functional Managers	Engineers	Blue Collar workers
1	0.16	0.5	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0.4	0.5	0
5	0	0	0	0	0
6	1	1	1	0	0
7	0.71	0	1	1	0
8	0	0.5	0.83	0	0
9	1	1	0.5	1	0
10	1	1	1	1	0.1
11	0	0	0	0	0
12	1	1	0.66	0.33	0
13	1	1	0.66	0.33	0
14	1	1	0.8	1	0
15	1	1	1	0.8	0.3
16	1	0	1	0	0
17	1	1	1	1	0.2
18	0.8	1	1	1	0.2
19	1	1	0	0	0
20	1	1	1	0	0
21	1	1	1	0.4	0
22	0.8	1	1	1	0
23	1	1	0.8	1	0
24	1	1	0.8	1	0
25	0.5	1	0.6	0	0
26	0.5	1	1	1	0
27	0.33	1	1	1	0
28	1	1	1	1	0.3
29	0	0	0	0	0
30	0.8	1	1	1	0.2
31	0.5	1	0.6	0	0
32	0.9	1	1	1	0
33	1	1	1	1	1
34	1	1	1	0.4	0
35	0.7	0.8	0.5	1	0.8
36	0.75	1	1	1	0.5
37	0.4	1	1	1	0
38	0.4	1	1	1	0
39	0.7	1	1	0.2	0

Appendix 4.1: Influence of Proponents

ID No.	MD/CEO	Eng/Prod Depts	Mrkt/Sales Depts	Customers	Env/Health	Tax inct/financing
1	5	1	1	2	1	3
2	5	2	5	4	3	3
3	3	5	1	4	1	3
4	5	5	2	2	4	5
5	1	3	1	5	4	3
6	5	4	2	1	1	2
7	5	4	2	4	1	2
8	4	5	1	1	3	3
9	4	5	3	3	2	4
10	5	4	1	1	5	4
11	5	5	1	4	1	4
12	5	4	3	4	3	4
13	5	4	3	4	3	4
14	5	3	1	1	2	4
15	5	5	3	3	5	1
16	5	2	1	4	2	4
17	5	4	3	4	5	3
18	5	4	4	3	3	4
19	3	5	1	4	5	1
20	5	4	4	4	2	5
21	5	4	4	4	2	5
22	5	4	5	3	3	3
23	5	3	1	1	2	4
24	5	3	4	4	5	3
25	5	3	1	1	2	3
26	5	4	3	4	4	2
27	5	4	1	3	5	4
28	5	2	3	3	1	1
29	4	5	4	2	1	4
30	5	4	4	3	3	4
31	5	3	1	1	2	3
32	5	4	1	4	3	4
33	5	4	3	3	1	3
34	5	3	4	4	5	4
35	4	3	1	1	1	5
36	5	4	1	3	4	1
37	5	5	3	4	1	1
38	5	5	3	4	1	1
39	5	4	3	1	1	2

Appendix 4.2: Strategic Motivations

ID No.	Prod. Costs	Labour costs	Increased Productivity	Product Quality	Customer Services	Domestic Market Share	Foreign Market Share	Competitive advantage	Increased Flexibility
1	3	4	3	2	1	4	2	1	1
2	5	1	5	4	4	2	4	1	3
3	3	2	1	5	5	3	1	4	1
4	4	2	3	5	5	5	5	2	2
5	4	2	3	4	5	3	1	4	3
6	4	5	3	2	1	1	1	1	1
7	5	4	5	5	4	3	3	3	3
8	3	4	5	3	2	2	3	2	1
9	4	3	4	3	3	4	3	3	3
10	4	4	4	4	1	1	4	3	1
11	4	5	5	5	4	4	1	1	4
12	5	3	3	5	3	3	5	2	1
13	5	3	3	5	3	3	5	2	1
14	3	3	3	1	1	1	1	1	1
15	5	5	4	1	3	3	4	4	1
16	2	4	4	4	2	4	4	2	1
17	5	2	5	5	5	5	4	4	1
18	4	3	3	4	2	2	2	3	3
19	2	3	2	2	4	3	1	3	4
20	4	3	5	5	5	5	4	4	4
21	4	3	5	5	5	5	4	4	4
22	5	5	5	5	4	5	5	3	2
23	3	3	3	1	1	1	1	1	1
24	4	4	2	4	3	2	5	4	1
25	3	3	3	4	4	1	4	4	1
26	5	5	5	5	3	1	5	2	1
27	5	5	5	5	5	1	5	2	5

28	3	4	5	4	2	5	2	1	1
29	5	2	5	5	4	4	2	4	1
30	4	3	3	4	2	2	2	3	3
31	3	3	3	4	4	1	4	4	1
32	4	4	5	4	4	1	4	1	2
33	5	4	5	5	4	4	5	4	3
34	4	3	5	5	5	5	5	4	1
35	5	1	5	5	1	3	1	3	5
36	2	4	4	4	3	2	1	3	4
37	5	3	5	5	5	5	1	3	4
38	5	3	5	5	5	5	1	3	4
39	4	3	5	4	4	5	1	4	2

Appendix 5.0: Impediments

ID No.	Tax	Finance	Foreign comp	Imports	Tech Support	In-house expertise	Equip	Cost	Labour Resist	Lack of confidence	Power supply	Govt Policy	Water Supply	Others
1	1	1		1	1	1		1			1	1		
2		1	1	1	1	1	1	1						
3		1			1	1		1						
4		1					1	1			1			1
5				1	1	1	1	1	1					
6					1	1	1	1		1				
7								1		1				
8						1	1							
9	1		1	1				1						
10		1			1	1	1	1	1	1				
11		1			1	1		1						
12		1			1	1	1	1		1				
13		1			1	1	1	1		1				
14					1	1	1			1				
15			1		1			1	1	1				
16		1			1		1	1						
17						1		1		1				
18	1			1				1		1				
19	1	1	1					1			1			
20					1			1			1			
21					1			1			1			
22		1		1	1	1		1	1	1	1			
23					1	1	1			1				
24						1		1						
25	1						1							
26					1	1	1	1		1				
27							1	1						

28						1	1	1		1	
29			1		1		1			1	1
30	1		1				1		1	1	
31	1					1					
32	1	1					1		1	1	
33					1		1	1			
34						1		1		1	
35		1		1	1						
36					1	1	1	1	1	1	
37		1			1	1	1			1	
38		1				1	1			1	
39					1		1	1			

Appendix 6.0: Flexibility

ID No.	Product	Mix	Volume	Delivery
1			1	1
2	1			1
3	1			1
4	1	1		
5	1	1		
6			1	1
7			1	1
8			1	1
9	1	1		1
10			1	1
11			1	1
12	1			1
13	1			1
14		1		
15			1	1
16		1		1
17			1	1
18	1	1		
19	1	1		
20			1	1
21			1	1
22			1	1
23		1		
24	1		1	
25	1		1	
26			1	1
27		1	1	
28		1		1
29		1		1
30	1	1		
31	1		1	
32			1	
33			1	1
34	1	1		
35	1		1	
36		1	1	
37		1	1	
38		1	1	
39			1	1

Appendix 7.0: Technical Collaboration

ID No	Local Firms	Foreign Firms	Research Institutions	Higher Institutions of learning
1	1			
2	1			
3	1			
4	1		1	
5	1			
6		1		
7		1	1	1
8	1			
9	1	1		1
10	1	1		
11	1			
12	1	1	1	1
13	1	1	1	1
14	1	1		
15	1	1	1	
16	1			
17	1	1		1
18		1		1
19				
20	1		1	
21	1		1	
22		1	1	1
23	1	1		
24	1	1		1
25	1		1	
26	1	1	1	1
27	1	1	1	1
28		1		
29	1			1
30		1		1
31	1		1	
32	1	1	1	
33	1			1
34	1	1		1
35		1	1	
36	1	1	1	1
37	1	1		1
38	1	1		1
39		1		1

Appendix 8.0 Descriptive statistics

Table 45: Cronbach's alpha reliability data

Item|	Obs	Sign	item-test correlation	item-rest correlation	average inter-item covariance	alpha
user	39	+	0.6246	0.6080	4.850687	0.8353
ims	39	+	0.9760	0.9623	2.802832	0.7275
sds	39	+	0.9046	0.8735	3.540876	0.7693
AMT	39	+	0.9959	0.9910	1.925349	0.7054
expctd	39	-	0.1080	0.0057	5.070171	0.8548
breadth	39	+	0.9505	0.8937	2.122660	0.7376
tvratio	39	+	0.0681	-0.0016	5.080162	0.8505
Test scale					3.627534	0.8228

Table 46: Detailed summary of IMS variable

	Ims			
	Percentiles	Smallest		
1%	0	0		
5%	0	0		
10%	0	0	Obs	39
25%	1	0	Sum of Wgt.	39
50%	4		Mean	3.923077
		Largest	Std. Dev.	3.012121
75%	7	8		
90%	8	8	Variance	9.072874
95%	10	10	Skewness	.2385944
99%	10	10	Kurtosis	1.952862

Table 47: Detailed summary of systems, devices and stations

	Sds			
	Percentiles	Smallest		
1%	0	0		
5%	0	0		
10%	0	0	Obs	39
25%	0	0	Sum of Wgt.	39
50%	1		Mean	1.717949
		Largest	Std. Dev.	2.051299
75%	4	5		
90%	5	6	Variance	4.207827
95%	6	6	Skewness	.7757876
99%	6	6	Kurtosis	2.229828

Table 48: Detailed summary of the AMT variable

	AMT			
	Percentiles	Smallest		
1%	0	0		
5%	0	0		
10%	0	0	Obs	39
25%	1	0	Sum of Wgt.	39
50%	4		Mean	5.641026
		Largest	Std. Dev.	4.814928
75%	10	13		
90%	13	13	Variance	23.18354
95%	14	14	Skewness	.3927655
99%	16	16	Kurtosis	1.874012

Table 49: Detailed summary of future plans for investment

	Expctd			
	Percentiles	Smallest		
1%	0	0		
5%	0	0		
10%	0	0	Obs	39
25%	0	0	Sum of Wgt.	39
50%	1		Mean	1.282051
		Largest	Std. Dev.	4.814928
75%	2	4		
90%	4	4	Variance	2.260459
95%	4	4	Skewness	.8742039
99%	5	5	Kurtosis	2.568981

Table 50: Summary of the ratio variable

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
Ratio	39	3.683761	3.229591	0	8

Table 51: Summary of $\sqrt{ratio}$ variable

Variable	Obs.	Mean	Std. Dev.	Min.	Max.
$\sqrt{ratio}$	39	1.631281	1.024498	0	2.828427

Table 52: Detailed summary of current investments and future plans

	Breadth			
	Percentiles	Smallest		
1%	0	0		
5%	0	0		
10%	1	0	Obs	39
25%	2	1	Sum of Wgt.	39
50%	6		Mean	6.923077
		Largest	Std. Dev.	4.874124
75%	11	14		
90%	14	14	Variance	23.75709
95%	14	14	Skewness	.1356875
99%	16	16	Kurtosis	1.68349

Table 53: Summary statistics of employee skills category

Employee category	Mean	Standard deviation	Median	Inter quartile range
Clerical employees	0.6653846	0.3877862	0.8	0.6
Secretaries	0.7641026	0.4094201	1.0	0.5
Functional Managers	0.7217949	0.3818781	1.0	0.5
Engineers	0.5630769	0.4617652	0.8	1.0
Blue collar workers	0.0923077	0.2216975	0.0	0.0

Table 54: Summary statistics for influence of proponents

Category	Mean	Standard deviation	Median	Inter quartile range
Managing director	4.692308	0.7997975	5	0
Engineering- Production	3.820513	0.9966205	4	2
Marketing-sales	2.384615	1.330124	3	2
Customers	2.948718	1.255487	3	2
Environmental	2.641026	1.477679	2	3
Tax incentives	3.153846	1.225571	3	2

Table 55: Summary statistics for the raw data of strategic motivation category

Strategy	Mean	Standard deviation	Median	Inter quartile range
Reduction in cost of finished product(s)	4	.9459053	4	2
Reduction in labour costs	3.333333	1.059626	3	1
Increase in overall productivity	4	1.123903	4	2
Increase in quality of product(s)	4.025641	1.245776	4	1
Increase in quality of customer services	3.358974	1.404639	4	3
Increased domestic market share	3.051282	1.520885	3	3
Increased foreign market share	2.974359	1.613874	3	3
Superior image of firm	2.74359	1.14059	3	2
Increase in flexibility of the manufacturing process	2.205128	1.360717	2	2

Appendix 8.1 Regression Analysis Models for Employee Skills

Table 56: Regression of employee skills on IMS

Poisson regression	Number of obs = 39
	Wald chi^2(5) = 58.73
Log pseudo-likelihood = -72.461573	Prob > χ^2 = 0.0000
	Pseudo R^2 = 0.3204

Ims	Coef.	Robust Std. Err.	Z	P>|z|	[95% Conf. Interval]	
CE	-.1330221	.3136613	-0.42	0.671	-.747787	.4817427
SEC	.7155787	.5191635	1.38	0.168	-.3019631	1.73312
MGR	1.071536	.4356841	2.46	0.014	.2176113	1.925462
ENG	.9337904	.314607	2.97	0.003	.3171721	1.550409
BCW	.129717	.240804	0.54	0.590	-.3422502	.6016842
Constant	-.7580846	.5799775	-1.31	0.191	-1.89482	.3786504

Goodness-of-fit χ^2 = 40.63001

Prob > χ^2(33) = 0.1696

AIC = 157

p(_hat) = 0.003

p(_hatsq) = 0.498

<u>Multivariable fractional polynomial (MFP) model IMS and employee skills</u>

Goodness-of-fit χ^2 = 33.13277

Prob > χ^2 (33) = 0.4608

AIC = 149

p(_hat) = 0.002

p(_hatsq) = 0.844

Table 57: Role of employee skills on SDS

Poisson regression	Number of obs = 39
	Wald chi^2(5) = 45.39
Log pseudo-likelihood = -45.391145	Prob > χ^2 = 0.0000
	Pseudo R^2 = 0.4497

Sds	Coef.	Robust Std. Err.	Z	P>|z|	[95% Conf. Interval]	
CE	-1.263989	.5166059	-2.45	0.014	-2.420332	-.1076462
SEC	1.559342	.8517929	1.83	0.067	-.4048327	3.523517
MGR	2.757178	1.159066	2.38	0.017	.4626105	5.051746
ENG	1.228381	.8481228	1.45	0.148	-.0337849	2.490547
BCW	1.291883	.3595	3.59	0.000	.4563443	2.127421
Constant	-3.673506	1.032354	-3.56	0.000	-5.958163	-1.388849

Goodness-of-fit χ^2 = 31.30464
Prob > χ^2(33) = 0.5517
AIC = 103
p(_hat) = 0.000
p(_hatsq) = 0.222

<u>MFP of SDS and employee skills model</u>

Goodness-of-fit χ^2 = 24.85393

Prob > χ^2 (33) = 0.8451

AIC = 96

p(_hat) = 0.009

p(_hatsq) = 0.431

Table 58: Role of employee skills on AMT

Poisson regression				Number of obs = 39		
				Wald chi^2(5) = 82.03		
				Prob > χ^2 = 0.0000		
Log pseudo-likelihood = -84.060289				Pseudo R^2 = 0.4339		
AMT	**Coef.**	**Robust Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
CE	-.4540473	.3136971	-1.45	0.148	-1.068882	.1607878
SEC	.9207842	.5548602	1.66	0.097	-.1667219	2.00829
MGR	1.407482	.4796869	2.93	0.003	.4673131	2.347651
ENG	.9875931	.3544497	2.79	0.005	.2928844	1.682302
BCW	.4954726	.2346926	2.11	0.035	.0354837	.9554616
Constant	-.7740898	.5913898	-1.31	0.191	-1.933193	.385013

Goodness-of-fit χ^2 = 55.49561
Prob > χ^2(33) = 0.0084
AIC = 180
p(_hat) = 0.001
p(_hatsq) = 0.574

<u>MFP of AMT and employee skills model</u>

Goodness-of-fit χ^2 = 43.91109

Prob > χ^2 (33) = 0.0971

AIC = 169

p(_hat) = 0.000

p(_hatsq) = 0.798

Table 59: Role of employee skills on current and future plans for investment

Poisson regression				Number of obs = 39		
				Wald chi^2(5) = 101.67		
Log pseudo-likelihood = -85.92658				Prob > χ^2 = 0.0000		
				Pseudo R^2 = 0.3968		
Breadth	**Coef.**	**Robust Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
CE	-.4187123	.2394173	-1.75	0.080	-.8879617	.0505371
SEC	1.032628	.4190492	2.46	0.014	.2113068	1.853949
MGR	.8584946	.3167848	2.71	0.007	.2376077	1.479381
ENG	.7071744	.2428517	2.91	0.004	.2311938	1.183155
BCW	.4269001	.1813435	2.35	0.019	.0714734	.7823269
Constant	.0532002	.3463493	0.15	0.878	-.625632	.7320324

Goodness-of-fit chi2 = 41.58045
Prob > chi2(33) = 0.1453
AIC = 184
p(_hat) = 0.008
p(_hatsq) = 0.548

MFP of breadth and employee skills model

Goodness-of-fit χ^2 = 31.63813

Prob > χ^2 (33) = 0.5349

AIC = 174

p(_hat) = 0.021

p(_hatsq) = 0.961

Table 60: Regression of employee skills on transformed ratio

0.9 Quantile regression	Number of obs = 39
Raw sum of deviations 9.337739 (about 2.8284271)	Pseudo R^2 = 0.2110
Min sum of deviations 7.367338	

Transformed Ratio	Coef.	Std. Err	T	P>|t	[95% Conf. Interval]	
CE	1.204781	.3202153	3.76	0.001	.5532985	1.856264
SEC	-1.349355	.1123486	-12.01	0.000	- 1.57793	- 1.12078
MGR	7.64e-09	.4034146	0.00	1.000	- .8207532	.8207532
ENG	4.14e-08	.2226248	0.00	1.000	- .4529335	.4529335
BCW	-1.748304	.1113218	-15.70	0.000	- 1.97479	- 1.521818
Constant	2.973001	.1209133	24.59	0.000	2.727001	3.219001

Table 61: Regression of employee skills on users of AMT's

Logit estimates	Number of obs = 13
Log likelihood = -5.8144005	LR chi2(5) = 6.32
	Prob > chi2 = 0.0972
	Pseudo R2 = 0.3520

User	Coef	Robust Std. Err	Z	P>|z|	[95% Conf. Interval]	
CE	3.39245	2.682215	1.26	0.206	-1.864595	8.649495
SEC	-0.775905	2.626079	-0.30	0.768	-5.922926	4.371116
MGR	1.813028	2.462318	0.74	0.462	-3.013026	6.639083
Constant	-1.711745	0.8351924	-2.05	0.040	-3.348691	-0.0747976

Table 62: Role of employee skills on expctd

Poisson regression				Number of obs = 39		
				Wald $chi^2(5)$ = 4.70		
Log pseudo-likelihood = -62.287976				Prob > χ^2 = 0.4530		
				Pseudo R^2 = 0.0462		
Expctd	**Coef.**	**Robust Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
CE	-.0662062	.6738896	-0.10	0.922	-1.387006	1.254593
SEC	1.202163	.6281612	1.91	0.056	-.0290107	2.433336
MGR	-.2950751	.698833	-0.42	0.673	-1.664763	1.074612
ENG	-.0190684	.3525938	-0.05	0.957	-.7101396	.6720028
BCW	-.1222585	.7000332	-0.17	0.861	-1.494298	1.249781
Constant	-.4369621	.5189807	-0.84	0.400	-1.454146	.5802214

Goodness-of-fit chi^2 = 68.76086

Prob > $chi^2(33)$ = 0.0003

Table 63: Comparison of employee skills models with corresponding multivariable fractional polynomial (MFP) models

Count outcomes (Poisson or Negative binomial regression), user – logistic and ratio - quantile

$$\ln(y_i) = \beta_0 + \beta_1 \times CE_i + \beta_2 \times SEC_i^2 + \beta_3 \times MGR_i + \beta_4 \times \sqrt{ENG_i} + \beta_5 \times \sqrt{BCW_i}$$

Multivariable fractional polynomial model

$$\ln(y_i) = \beta_0 + \beta_1 \times CE_i + \beta_2 \times SEC_i + \beta_3 \times MGR_i + \frac{\beta_4}{ENG^2} + \beta_5 \times BCW_i$$

	variables	β	prob	G.O.F	AIC	_hat	_hatsq	variables	β	prob	G.O.F	AIC	_hat	_hatsq
user	Prob > χ^2 = 0.0972 insignificant				20	0.151	0.673							
ims	MGR	1.07	0.014	17%	157	0.003	0.498	MGR	0.974	0.030	46%	149	0.002	0.844
	ENG	0.93	0.003					ENG	-.007	0.000				
sds	CE	-1.26	0.014	55%	103	0.000	0.222	CE	-1.18	0.008	85%	96	0.009	0.431
	MGR	2.76	0.017					MGR	2.87	0.006				
	BCW	1.29	0.000					ENG	-0.02	0.001				
								BCW	1.28	0.000				
AMT	MGR	1.41	0.003	0.84%	180	0.001	0.574	CE	-0.54	0.044	9.7%	169	0.000	0.798
	ENG	0.99	0.005					MGR	1.36	0.005				
	BCW	0.50	0.035					ENG	-0.01	0.000				
								BCW	0.56	0.005				
expctd	Insignificant models (Prob > χ^2 = 0.45 and 0.39 respectively)													
breadth	SEC	1.03	0.014	15%	184	0.008	0.548	CE	-0.47	0.016	53%	174	0.021	0.961
	MGR	0.86	0.007					SEC	1.00	0.017				
	ENG	0.71	0.004					MGR	0.77	0.008				
	BCW	0.43	0.019					ENG	-0.01	0.000				
								BCW	0.41	0.011				
ratio	CE	1.20	0.001	-	-	0.793	0.603						0.730	0.645
	SEC	-1.35	0.000											
	BCW	-1.75	0.000											

Key:

CE – Clerical Employees

SEC – Secretaries

MGR – Functional Managers

ENG – Engineers

BCW – Blue collar workers

Table 64: Stepwise estimation of the employee skills' models (manual method)

	Prob > χ^2	Psuedo r^2	Predictors	β	std. err.	prob	G.O.F	AIC	_hat	_hatsq
ims	0.0000	0.3023	ENG	1.09	0.29	0.000	16%	155	0.002	0.201
			MGR	1.35	0.43	0.002				
sds	0.0000	0.4082	MGR	3.28	1.09	0.003	33%	106	0.000	0.342
			ENG	1.61	0.62	0.009				
			BCW	0.92	0.37	0.013				
AMT	0.0000	0.4163	MGR	1.65	0.46	0.000	nbreg	182	0.001	0.342
			ENG	1.39	0.32	0.000				
expctd	0.0186	0.0424	SEC	0.95	0.45	0.035	0.1%	129	0.088	0.322
breadth	0.0000	0.3790	SEC	0.81	0.29	0.005	9%	185	0.048	0.894
			MGR	0.87	0.34	0.010				
			ENG	0.84	0.21	0.000				
ratio	-	0.2110	CE	1.20	0.29	0.000	-	-	0.793	0.603
			SEC	-1.35	0.13	0.000				
			BCW	-1.75	0.11	0.000				

Key:

CE – Clerical Employees

SEC – Secretaries

MGR – Functional Managers

ENG – Engineers

BCW – Blue collar workers

Table 65: Stepwise estimation of the employee skills' models (MFP method)

	Prob > χ^2	Psuedo r^2	Predictors	β	std. err.	prob	G.O.F	AIC	_hat	_hatsq
			SEC	0.88	0.39	0.024				
ims	0.0000	0.2825	MGR	1.35	0.44	0.002	6.2%	161	0.010	0.892
			ENG	0.44	0.21	0.036				
			MGR	3.69	1.08	0.001				
sds	0.0000	0.3700	ENG	0.84	0.39	0.030	13%	112	0.000	0.462
			BCW	1.06	0.39	0.006				
			SEC	0.91	0.43	0.033				
AMT	0.0000	0.3745	MGR	1.62	0.48	0.001	nbreg	143	0.011	0.714
			ENG	0.61	0.24	0.012				
expctd	0.0144	0.0459	SEC	1.05	0.49	0.031	0.12%	129	0.149	0.630
			SEC	1.02	0.30	0.001				
breadth	0.0000	0.3461	MGR	1.11	0.32	0.001	1.2%	194	0.149	0.405
			ENG	0.39	0.16	0.012				
ratio	-	0.1348	BCW	-1.75	0.05	0.000	-	-	0.730	0.645

Key:

CE – Clerical Employees

SEC – Secretaries

MGR – Functional Managers

ENG – Engineers

BCW – Blue collar workers

Appendix 8.2 Regression Analysis Models for Internal and external influences

Table 66: Model of internal/external influences on users of AMT's

Logit estimates	Number of obs = 13
Log likelihood = -13.849406	LR chi2(6) = 15.93
	Prob > chi2 = 0.0141
	Pseudo R2 = 0.2454

user	Coef	Robust Std. Err	Z	P>|z|	[95% Conf. Interval]	
Managing Director	0.0335933	0.016837	2.00	0.046	0.0005940	0.0665926
Engineering-Production	0.0642856	0.077945	0.82	0.410	-0.0884837	0.2170550
Marketing-sales	-0.0376065	0.0997585	-0.38	0.706	-0.2331295	0.1579165
Customers	-0.0114048	0.0180258	-0.63	0.527	-0.0467346	0.0239251
Environmental	0.1523405	0.0561573	2.71	0.007	0.0422741	0.2624068
Tax incentives	0.0315024	0.0592982	0.53	0.595	-0.0847199	0.1477248
Constant	-3.577419	2.836738	-1.26	0.207	-9.1373240	1.9824860

_hat = 0.074
_hatsq = 0.667

Table 67: Model of Internal and external influences on IMS

Poisson regression	Number of obs = 39
	Wald $chi^2(6)$ = 36.52
	Prob > χ^2 = 0.0000
	Pseudo R^2 = 0.2333
Log pseudo-likelihood =-81.75175	

IMS	Coef.	Robust Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Managing Director	0.0165172	0.004314	3.83	0.000	0.008062	0.0249724
Engineering-Production	0.0395669	0.016473	2.40	0.016	0.007280	0.0718535
Marketing-sales	0.0097829	0.0142462	0.69	0.492	-0.018139	0.0377049
Customers	0.0000648	0.0035473	0.02	0.985	-0.006888	0.0070173
Environmental	0.0387798	0.0093006	4.17	0.000	0.020550	0.0570088
Tax incentives	-0.0058305	0.0137069	-0.43	0.671	-0.032696	0.0210346
Constant	-1.621556	0.7051195	-2.30	0.021	-3.003565	-0.2395471

Goodness-of-fit χ^2 = 59.21036
Prob > χ^2 = 0.0024
_hat = 0.008
_hatsq = 0.257

Table 68: Model of internal and external influences on SDS

Poisson regression				Number of obs = 39		
				Wald chi^2(6) = 21.20		
Log pseudo-likelihood = -60.913447				Prob > χ^2 = 0.0017		
				Pseudo R^2 = 0.2615		
SDS	**Coef.**	**Robust Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Managing Director	0.0294688	0.0147883	1.99	0.046	0.0004843	0.058453
Engineering-Production	0.0424507	0.0193348	2.20	0.028	0.0045552	0.080346
Marketing-sales	0.0219501	0.0225415	0.97	0.330	-0.0222305	0.066131
Customers	-0.0065979	0.0055483	-1.19	0.234	-0.0174725	0.004277
Environmental	0.0376908	0.0137039	2.75	0.006	0.0108316	0.064550
Tax incentives	-0.0538491	0.0179018	-3.01	0.003	-0.088936	-0.018762
Constant	-3.448544	2.044581	-1.69	0.092	-7.455849	0.558762
Goodness-of-fit χ^2	=	62.34925				
Prob > χ^2	=	0.0010				
_hat	=	0.000				
_hatsq	=	0.643				

Table 69: Model of internal/external influences on AMT

Negative binomial regression				Number of obs = 39		
				LR chi^2(6) = 21.87		
Log pseudo-likelihood = -98.746263				Prob > χ^2 = 0.0013		
				Pseudo R^2 = 0.0997		
AMT	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Managing Director	0.0192364	0.0055929	3.44	0.001	0.0082746	0.0301983
Engineering-Production	0.0490547	0.0206985	2.37	0.018	0.0084865	0.089623
Marketing-sales	0.0202655	0.0202246	1.00	0.316	-0.019374	0.059905
Customers	-0.0040223	0.0049047	-0.82	0.412	-0.0136353	0.0055907
Environmental	0.0411417	0.0129243	3.18	0.001	0.0158105	0.0664728
Tax incentives	-0.0165412	0.0163965	-1.01	0.313	-0.0486778	0.0155955
Constant	-1.588644	0.8728348	-1.82	0.069	-3.299369	0.1220802
/lnalpha	-1.174037	0.4895965			-2.133629	-0.2144458
alpha	0.3091164	0.1513423			0.1184068	0.8069885
Likelihood-ratio test of alpha=0: chibar2(01) = 14.74 Prob>=chibar2 = 0.000						
_hat	=	0.076				
_hatsq	=	0.791				

Table 70: Model of internal/external influences on planned investments

Poisson regression				Number of obs = 39		
				Wald chi^2(6) = 17.39		
Log pseudo-likelihood = -56.840797				Prob > χ^2 = 0.0079		
				Pseudo R^2 = 0.1296		
Expctd	**Coef.**	**Robust Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Managing Director	0.0021659	0.0054407	0.40	0.691	-0.0084976	0.0128295
Engineering-Production	-0.0434976	0.0239388	-1.82	0.069	-0.0904169	0.0034216
Marketing-sales	0.0386595	0.0231982	1.67	0.096	-0.0068082	0.0841272
Customers	-0.0118638	0.0077485	-1.53	0.126	-0.0270507	0.003323
Environmental	0.0199724	0.0218778	0.91	0.361	-0.0229074	0.0628522
Tax incentives	0.0534782	0.0207097	2.58	0.010	0.012888	0.0940683
Constant	-0.1487009	0.9086528	-0.16	0.870	-1.929628	1.632226
Goodness-of-fit χ^2	=	57.8665				
Prob > χ^2 (32)	=	0.0034				
_hat	=	0.003				
_hatsq	=	0.125				

Table 71: Model of internal/external influences on current and future investments

Negative binomial regression				Number of obs = 39		
				LR chi2(6) = 25.63		
Log pseudo-likelihood = -102.0914				Prob > χ^2 = 0.0003		
				Pseudo R^2 = 0.1115		
Breadth	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Managing Director	0.0157132	0.0043511	3.61	0.000	0.0071852	0.0242412
Engineering-Production	0.031942	0.015781	2.02	0.043	0.0010118	0.0628721
Marketing-sales	0.0222772	0.0153094	1.46	0.146	-0.0077287	0.0522831
Customers	-0.0056945	0.0038385	-1.48	0.138	-0.0132178	0.0018287
Environmental	0.035543	0.010187	3.49	0.000	0.0155769	0.0555092
Tax incentives	-0.0065028	0.0129889	-0.50	0.617	-0.0319607	0.018955
Constant	-0.6674689	0.6740588	-0.99	0.322	-1.9886	0.6536621
/lnalpha	-1.844923	0.5449171			-2.912941	-0.7769054
alpha	0.1580375	0.0861173			0.0543157	0.4598268
Likelihood-ratio test of alpha=0: chibar^2(01) = 8.34 Prob>=chibar^2 = 0.002						
_hat	=	0.041				
_hatsq	=	0.478				

Table 72: Model of internal/external influences on IMS/SDS ratio

Median regression — Number of obs = 39

Raw sum of deviations 33.18747 (about 1.5275252) — Pseudo R2 = 0.1607

Min sum of deviations 27.85521

Ratio	Coef.	Std. Err	T	P>|t	[95% Conf. Interval]	
Managing Director	0.0215107	0.0037779	5.69	0.000	0.0138154	0.0292059
Engineering-Production	-0.0169037	0.0156852	-1.08	0.289	-0.0488534	0.015046
Marketing-sales	-0.0405367	0.0180332	-2.25	0.032	-0.077269	-0.0038043
Customers	0.0086216	0.0040797	2.11	0.042	0.0003117	0.0169316
Environmental	-0.0126205	0.0118243	-1.07	0.294	-0.0367059	0.0114649
Tax incentives	0.0576095	0.0148729	3.87	0.000	0.0273143	0.0879046
Constant	-1.175309	0.6434297	-1.83	0.077	-2.485932	0.1353145

_hat = 0.000
_hatsq = 0.000

MFP of ratio and internal/external influences' model

_hat = 0.392
_hatsq = 0.854

Table 73: Stepwise estimation of the proponents' models (manual method)

	Prob > χ^2	Psuedo r^2	Predictors	β	std. err.	prob	G.O.F	AIC	_hat	_hatsq
user	0.0366	0.1190	MD	0.02	0.01	0.040	-	36	0.229	0.472
			MD	0.02	0.00	0.000				
ims	0.0000	0.2290	ENG	0.04	0.01	0.004	0.52%	172	0.009	0.221
			ENV	0.04	0.01	0.000				
sds	0.0082	0.0505	MD	0.03	0.01	0.021	nbreg	137	0.995	0.989
			MD	0.02	0.01	0.000				
AMT	0.0002	0.0909	ENG	0.05	0.02	0.016	nbreg	209	0.104	0.938
			ENV	0.04	0.01	0.004				
expctd	0.0377	0.0354	TAX	0.07	0.03	0.04	nbreg	124	0.004	0.025
			MD	0.02	0.01	0.000				
breadth	0.0001	0.0970	ENG	0.03	0.02	0.048	nbreg	218	0.156	0.857
			ENV	0.03	0.00	0.002				

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

Appendix 8.3 Regression Analysis Models for Strategic Motivations

Table 74: Model of strategic motivations on users of AMT's

			Number of obs = 39			
Logit estimates			LR chi2(9) = 36.71			
Log likelihood = -2.878e-07			Prob > chi^2 = 0.0000			
			Pseudo R^2 = 1.0000			
User	**Coef**	**Std. Err**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Reduction in product costs	44.97249	-	-	-	-	-
Reduction in labour costs	55.57292	4032.803	0.01	0.989	-7848.575	7959.72
Increase in overall productivity	30.2865	9650.791	0.00	0.997	-18884.92	18945.49
Increased quality of products	-14.14943	1239.831	-0.01	0.991	-2444.174	2415.88
Increased quality of customer services	-86.32431	13189.96	-0.01	0.995	-25938.16	25765.52
Increased domestic market share	-234.9457	30900.08	-0.01	0.994	-60797.99	60328.1
Increased foreign market share	1.9852	192.42	0.01	0.992	-375.1585	379.13
Superior firm image	99.36022	11908.05	0.01	0.993	-23239.98	23438.7
Increased flexibility of manufacture	3.769762	1214.245	0.00	0.998	-2376.107	2383.65
Constant	-44.80161	-	-	-	-	-

Table 75: Model of strategic motivations on Integrative and managerial systems

Negative binomial regression				Number of obs = 39		
				LR chi2(9) = 12.71		
Log pseudo-likelihood = -89.008282				Prob > χ^2 = 0.1761		
				Pseudo R^2 = 0.0666		
Ims	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Reduction in product costs	0.0058693	0.1596061	0.04	0.971	-0.306953	0.3186915
Reduction in labour costs	0.1523555	0.1502878	1.01	0.311	-0.1422033	0.4469142
Increase in overall productivity	0.1987993	0.1478955	1.34	0.179	-0.0910706	0.4886691
Increased quality of products	-0.0103277	0.0249264	-0.41	0.679	-0.0591826	0.0385272
Increased quality of customer services	-0.4747555	0.407144	-1.17	0.244	-1.272743	0.3232321
Increased domestic market share	-0.3082288	0.7159968	-0.43	0.667	-1.711557	1.095099
Increased foreign market share	0.0061607	0.0035687	1.73	0.084	-0.0008339	0.013155
Superior firm image	0.5705258	0.2894954	1.97	0.049	0.0031253	1.137926
Increased flexibility of manufacture	0.0229318	0.0201254	1.14	0.255	-0.0165132	0.062377
Constant	0.2030296	1.14254	0.18	0.859	-2.036307	2.442366
/lnalpha	-1.380017	0.5717942			-2.500713	-0.259321
alpha	0.2515742	0.1438487			0.0820265	0.771575

Likelihood-ratio test of alpha=0: chibar2(01) = 7.18 Prob>=chibar2 = 0.004
_hat = 0.012
_hatsq = 0.059

Table 76: Model of strategic motivations on SDS

Poisson regression	Number of obs = 39 Wald chi^2(9) = 29.18
Log pseudo-likelihood = -63.57865	Prob > χ^2 = 0.0006 Pseudo R^2 = 0.2292

SDS	Coef.	Robust Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Reduction in product costs	0.1509993	0.236369	0.64	0.523	-0.3122754	0.6142739
Reduction in labour costs	0.5339153	0.2601045	2.05	0.040	0.0241198	1.043711
Increase in overall productivity	0.2364113	0.2509482	0.94	0.346	-0.2554381	0.7282607
Increased quality of products	0.0109007	0.0286132	0.38	0.703	-0.0451801	0.0669815
Increased quality of customer services	-0.761148	0.4273607	-1.78	0.075	-1.59876	0.0764636
Increased domestic market share	0.4920355	0.886848	0.55	0.579	-1.246155	2.230226
Increased foreign market share	-0.0035244	0.0052071	-0.68	0.499	-0.0137301	0.0066813
Superior firm image	1.781391	0.6037275	2.95	0.003	0.5981064	2.964675
Increased flexibility of manufacture	0.0247971	0.0209084	1.19	0.236	-0.0161825	0.0657768
Constant	-3.906058	1.704607	-2.29	0.022	-7.247027	-0.5650897

Goodness-of-fit chi^2	=	67.67965
Prob > chi^2(29)	=	0.0001
_hat	=	0.000
_hatsq	=	0.632

Table 77: Model of strategic motivations on penetration of AMT's

Negative binomial regression				Number of obs = 39		
				LR $chi^2(9)$ = 12.86		
				Prob > χ^2 = 0.1690		
Log pseudo-likelihood = -103.24886				Pseudo R^2 = 0.0586		
AMT	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Reduction in product costs	0.0522457	0.191628	0.27	0.785	-0.3233378	0.4278293
Reduction in labour costs	0.2398005	0.1932137	1.24	0.215	-0.1388914	0.6184924
Increase in overall productivity	0.2528087	0.1777914	1.42	0.155	-0.0956561	0.6012735
Increased quality of products	-0.00544	0.0309769	-0.18	0.861	-0.0661537	0.0552737
Increased quality of customer services	-0.603234	0.4997663	-1.21	0.227	-1.582758	0.37629
Increased domestic market share	-0.3204125	0.8957771	-0.36	0.721	-2.076103	1.435278
Increased foreign market share	0.0049438	0.0043885	1.13	0.260	-0.0036575	0.0135451
Superior firm image	0.7695051	0.3451036	2.23	0.026	0.0931145	1.445896
Increased flexibility of manufacture	0.0255753	0.0255966	1.00	0.318	-0.0245931	0.0757436
Constant	-0.1590859	1.394744	-0.11	0.909	-2.892734	2.574563
/lnalpha	-0.6169046	0.3660199			-1.33429	0.1004812
alpha	0.5396122	0.1975088			0.263345	1.105703

Likelihood-ratio test of alpha=0: chibar2(01) = 35.23 Prob>=chibar2 = 0.000
_hat = 0.026
_hatsq = 0.120

Table 78: Model of strategic motivations on future plans for investment in AMT's

Poisson regression	Number of obs = 39
	Wald chi^2(9) = 22.18
Log pseudo-likelihood = -56.401981	Prob > χ^2 = 0.0083
	Pseudo R^2 = 0.1363

Expctd	Coef.	Robust Std. Err.	Z	P>|z|	[95% Conf. Interval]	
Reduction in product costs	0.1163986	.2833428	0.41	0.681	-0.4389431	0.671740
Reduction in labour costs	-0.3773822	0.1542121	-2.45	0.014	-0.6796323	-0.075132
Increase in overall productivity	0.0073925	0.2702932	0.03	0.978	-0.5223724	0.537157
Increased quality of products	-0.0005305	0.0277022	-0.02	0.985	-0.0548259	0.0537649
Increased quality of customer services	-0.8030494	0.4323297	-1.86	0.063	-1.6504	0.0443012
Increased domestic market share	1.379555	0.8766798	1.57	0.116	-0.3387061	3.097816
Increased foreign market share	0.0078111	0.006426	1.22	0.224	-0.0047836	0.0204058
Superior firm image	-0.0885753	0.3812656	-0.23	0.816	-0.8358422	0.6586915
Increased flexibility of manufacture	-0.0098834	0.0348346	-0.28	0.777	-0.0781579	0.0583912
Constant	1.133287	1.50581	0.75	0.452	-1.818047	4.084621

Goodness-of-fit chi2	=	56.98887
Prob > chi2(29)	=	0.0014
_hat	=	0.000
_hatsq	=	0.016

Table 79: Model of strategic motivations on current and future investments

Poisson regression				Number of obs = 39		
				LR chi2(9) = 30.81		
				Prob > χ^2 = 0.0003		
Log pseudo-likelihood = -121.20356				Pseudo R^2 = 0.1491		
breadth	**Coef.**	**Robust Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Reduction in product costs	0.0852453	0.1812191	0.47	0.638	-0.2699375	0.4404281
Reduction in labour costs	0.083077	0.1198915	0.69	0.488	-0.1519061	0.31806
Increase in overall productivity	0.1581765	0.1154206	1.37	0.171	-0.0680437	0.3843968
Increased quality of products	-0.0111051	0.0153833	-0.72	0.470	-0.0412559	0.0190457
Increased quality of customer services	-0.4891332	0.2898831	-1.69	0.092	-1.057294	0.0790272
Increased domestic market share	0.2435934	0.5014416	0.49	0.627	-0.739214	1.226401
Increased foreign market share	0.0044383	0.003254	1.36	0.173	-0.0019394	0.010816
Superior firm image	0.5925886	0.2263151	2.62	0.009	0.1490191	1.036158
Increased flexibility of manufacture	0.0155069	0.013308	1.17	0.244	-0.0105764	0.0415901
Constant	0.6647033	0.8774478	0.76	0.449	-1.055063	2.384469
Goodness-of-fit chi2	=	112.1344				
Prob > chi2(29)	=	0.0000				
_hat	=	0.012				
_hatsq	=	0.055				

Table 80: Model of strategic motivations on IMS/SDS ratio

0.7 Quantile regression				Number of obs = 39		
Raw sum of deviations 28.01322 (about 2.8284271) Min sum of deviations 18.67156				Pseudo R^2 = 0.3335		
Transformed ratio	**Coef.**	**Std. Err.**	**Z**	**P>|z|**	**[95% Conf. Interval]**	
Reduction in product costs	0.155127	0.3975651	0.39	0.699	-0.6579849	0.9682389
Reduction in labour costs	0.0397749	0.3295843	0.12	0.905	-0.6343007	0.7138505
Increase in overall productivity	-0.0543732	0.3741385	-0.15	0.885	-0.8195723	0.7108259
Increased quality of products	-0.0782256	0.0592216	-1.32	0.197	-0.1993474	0.0428962
Increased quality of customer services	-0.8858759	0.8540906	-1.04	0.308	-2.632687	0.8609354
Increased domestic market share	-3.121186	1.420173	-2.20	0.036	-6.025766	-0.216606
Increased foreign market share	0.0122466	0.0079919	1.53	0.136	-0.0040988	0.0285919
Superior firm image	-0.8974651	0.5907206	-1.52	0.140	-2.105624	0.3106941
Increased flexibility of manufacture	0.0350649	0.0643034	0.55	0.590	-0.0964504	0.1665803
Constant	6.444817	2.61355	2.47	0.020	1.099508	11.79013

Table 81: Stepwise estimation of the production strategy models (manual method)

	Prob > χ^2	Psuedo r^2	Predictors	β	std. err.	prob	G.O.F	AIC	_hat	_hatsq
user										
ims	0.0334	0.0356	LBCT	0.28	0.14	0.041	nbreg	192	0.369	0.709
			CPADV	0.61	0.28	0.029				
sds	0.0135	0.0622	LBCT	0.44	0.21	0.036	nbreg	138	0.012	0.961
			CPADV	1.31	0.49	0.008				
AMT	0.0211	0.0352	LBCT	0.33	0.16	0.038	nbreg	220	0.401	0.777
			CPADV	0.80	0.33	0.014				
expctd	0.0111	0.0690	LBCT	-0.28	0.14	0.045	0.18%	128	0.022	0.326
			DMRT	1.83	0.67	0.006				
breadth	0.0322	0.0459	PRD	0.27	0.12	0.029	nbreg	231	0.008	0.024
			CUSTSQ	-0.72	0.36	0.048				
			FMRT	0.01	0.00	0.033				
			CPADV	0.58	0.27	0.028				

Key:

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)

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

Appendix 8.4 Results of interactions between technical skills and production strategies

Table 82: Moderating roles of production strategies on employee skills (SDS)

Dependent variable: SDS	Full Model with interactions β	
Employee skills		
Clerical employees	-3.87*	-3.96***
Secretaries	-22.6***	
Functional managers	20.3***	
Engineers		
Blue collar workers		2.84*
Production strategies		
Labour Cost reduction	-4.61***	
Domestic Market		-41.4**
Competitive advantage	1.06***	1.19**
Interaction factors	**Labour**	**Dom. Mrkt**
Clerical employees		3.94**
Secretaries	8.94***	
Functional managers	-4.73**	
Engineers		
Blue collar workers		
Psuedo R^2	54.8%****	54.1%****
Goodness of fit	93.9%	90.6%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Table 83: Moderating roles of production strategies on employee skills (AMT)

Dependent variable: AMT	Full Model with interactions β		
Employee skills			
Clerical employees		-1.66***	-2.04**
Secretaries	-6.32****		
Functional managers	5.89***	-4.48***	3.51***
Engineers	3.16**		1.38**
Blue collar workers			
Production strategies			
Labour Cost reduction			
Domestic Market		-14.16*	
Competitive advantage	0.59****	0.55***	-1.32*
Interaction factors	**Labour**	**Dom. Mrkt**	**Competitive Advantage**
Clerical employees	-0.54*	1.99**	1.9*
Secretaries	1.98****		
Functional managers	-1.38**	9.99***	
Engineers		2.09**	
Blue collar workers			
Psuedo R^2	50.8%****	52.4%****	49.7%****
Goodness of fit	12.2%	27.0%	6.1%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Table 84: Moderating roles of production strategies on employee skills (ratio)

Dependent variable: transformed ratio	Full Model with interactions β		
Employee skills			
Clerical employees	9.34****	2.99**	
Secretaries			3.00*
Functional managers		-4.65**	
Engineers	5.48***		
Blue collar workers	-6.40***		-3.38**
Production strategies			
Labour Cost reduction			
Domestic Market	-1.13**		-1.66**
Competitive advantage		-0.67*	
Interaction factors	**Labour**	**Dom. Mrkt**	**Competitive Advantage**
Clerical employees	-2.16***		3.94*
Secretaries			-3.46*
Functional managers		9.17**	
Engineers	-1.52***		
Blue collar workers	1.34**		
R^2	74.2%	64.7%	67.9%****

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Appendix 8.5 Results of interactions between technical skills and influences of proponents

Table 85: Moderating roles of Influence of proponents on employee skills (SDS)

Dependent variable: SDS	Full Model with interactions β				
Employee skills					
Clerical employees		-0.94*	-2.24*	-3.64****	**N**
Secretaries		-3.29*		3.17***	**O**
Managers		3.24**	3.25**	4.12**	**T**
Engineers		3.66***			
Blue collar workers		1.45**	4.93****	2.57****	**C**
Influences					**O**
MD/CEO			0.03**		**N**
Engineering			0.02*		**C**
Marketing					**A**
Customers			-0.16***		**V**
Environmental	0.03**	0.04***			**E**
Taxes					
Interaction factors	**ENG**	**MRKT**	**Cust**	**ENV**	**TAX**
Clerical employees		-0.23**		0.17****	
Secretaries		1.10***	0.08**	-0.21**	
Managers		-0.51**			
Engineers		-0.33**	0.06****		
Blue collar workers			-0.12***	-0.11****	
Psuedo R^2	49%****	51%****	54%****	53%****	
Goodness of fit	27.7%	52.4%	77.7%	71.2%	

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Table 86: Moderating roles of Influence of proponents on employee skills (AMT)

Dependent variable: AMT	**Full Model with interactions β**				
Employee skills					
Clerical employees	1.62*			-0.89**	-1.53***
Secretaries				1.57****	2.94****
Managers		1.59*	2.55***	2.32***	1.74*
Engineers		1.37**	1.39***		
Blue collar workers	1.83*	1.07***	1.28****	1.09****	1.26***
Influences					
MD/CEO			0.01*		
Engineering		0.03**	0.03**	0.03**	0.02*
Marketing					
Customers			-0.03**		
Environmental	0.03****	0.02***		0.11***	0.03****
Taxes					
Interaction factors	**ENG**	**MRKT**	**Cust**	**ENV**	**TAX**
Clerical employees	-0.10*			0.06****	0.12****
Secretaries		0.39*	0.04***	-0.11***	-0.19****
Managers			-0.03*		
Engineers					0.08**
Blue collar workers			-0.03****	-0.06**	-0.05***
Psuedo R^2	51%****	52%****	54%****	53%****	52%****
Goodness of fit	4.9%	9.5%	42.0%	18.0%	13.1%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Table 87: Moderating roles of Influence of proponents on employee skills (Ratio)

Dependent variable: Transformed ratio	Full Model with interactions β					
Employee skills						
Clerical employees	3.93****	4.21***	2.31**	2.38*	3.01***	
Secretaries		-2.83***		-4.33***	-1.34***	
Managers	6.50****	-3.28*		2.38*	0.89*	
Engineers	-4.09****					
Blue collar workers			-1.98***	-2.65****	-1.80****	-1.32*
Influences						
MD/CEO						
Engineering						
Marketing				-.040**		
Customers		-0.01*		-0.02*		
Environmental				-0.03*	0.09*	
Taxes						
Interaction factors	**MD**	**ENG**	**MRKT**	**Cust**	**ENV**	**TAX**
Clerical employees	-0.01*				-0.08*	
Secretaries	-0.01**			0.07***		
Managers	-0.05***	0.21**				
Engineers	0.04***				-0.12*	
Blue collar workers						
R^2	71%***	75%****	60%****	77%****	64%****	59%****

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Appendix 8.6 Results of interactions between influences of proponents and production strategies

Table 88: Moderating roles of production strategies on Influence of proponents (SDS)

Dependent variable: SDS	**Full Model with interactions β**		
Influences			
MD/CEO			
Engineering		-0.25***	
Marketing	**N**		-0.21**
Customers	**O**	-0.04**	0.03**
Environmental	**T**	-0.07**	0.23****
Taxes		-0.16	-0.27***
Production strategies			
Labour Cost reduction		-0.35*	
Domestic Market			
Competitive advantage		1.49***	
Interaction factors	**Labour cost reduction**	**Domestic Market**	**Competitive advantage**
MD/CEO	**C**		
Engineering	**O**	0.50***	
Marketing	**N**		0.22**
Customers	**C**	0.06***	-0.03**
Environmental	**A**	0.14**	-0.14***
Taxes	**V**	0.20**	0.16**
Psuedo R^2	E	44.6%****	37.6%****
Goodness of fit		10.3%	0.6%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Table 89: Moderating roles of production strategies on Influence of proponents (AMT)

Dependent variable: AMT	**Full Model with interactions β**		
Influences			
MD/CEO			
Engineering		-0.13*	
Marketing			-0.16***
Customers		-0.03***	0.01*
Environmental			0.17****
Taxes		-0.08**	-0.15***
Production strategies			
Labour Cost reduction		-0.24*	-0.29**
Domestic Market			
Competitive advantage		0.72**	-6.71**
Interaction factors	**Labour cost reduction**	**Domestic Market**	**Competitive advantage**
MD/CEO			0.04**
Engineering		0.29**	
Marketing			0.17***
Customers		0.04***	-0.02**
Environmental		0.08**	-0.10***
Taxes			0.10**
Psuedo R^2	13.6%**	41.8%****	39.4%****
Goodness of fit	NA	0.0%	0.0%

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Table 90: Moderating roles of production strategies on Influence of proponents (Ratio)

Dependent variable: Transformed ratio	**Full Model with interactions β**		
Influences			
MD/CEO	0.09****		-0.09***
Engineering			
Marketing	-0.13***		
Customers	0.05***		-0.02*
Environmental			
Taxes	0.26***		
Production strategies			
Labour Cost reduction	5.20****		
Domestic Market			
Competitive advantage			-12.43****
Interaction factors	**Labour cost reduction**	**Domestic Market**	**Competitive advantage**
MD/CEO	-0.03****		0.08***
Engineering	-0.04*		0.08*
Marketing	0.03**		
Customers	-0.01**		0.03***
Environmental			
Taxes	-0.06**		
Psuedo R^2	70.8%****	37%*	72.8%****

*p < 0.10, **p < 0.05, ***p < 0.01, ****p < 0.001

Appendix 9.0 Validation questionnaire

MAKERERE UNIVERSITY

COLLEGE OF ENGINEERING ART & DESIGN

DEPARTMENT OF MECHANICAL ENGINEERING

EXPERT OPINION QUESTIONNAIRE (academic)

Following a survey carried out in the manufacturing industry in Uganda concerning the degree of penetration of advanced manufacturing technologies (AMT's), models were developed explaining this industry. The purpose of this brief questionnaire is to present the results and obtain your expect opinion regarding them. Your response will help the research team validate the results and better inform policy dialogue relevant to improving performance in this crucial sector.

TICK THE APPROPRIATE BOX

Hardware equipment

1. The levels of education of the following categories of employees are considered very instrumental in the acquisition and/or use of **hardware equipment** related to Advanced Manufacturing Technologies in your firm.

	Strongly agree	Agree	Disagree	Strongly Disagree
Secretaries				
Functional Managers				
Engineers				
Blue collar workers				
Others - -				

2. The following individuals, departments and factors have a positive influence in your firm towards the adoption of **hardware equipment** related to Advanced Manufacturing Technologies.

	Strongly agree	Agree	Disagree	Strongly Disagree
Managing Director/CEO				
Engineering/Production Department(s)				
Environmental and health issues				
Tax incentives/Favourable financing				
Others - -				

3. The following strategic motivations have a positive impact in your firm towards the adoption of **hardware equipment** related to Advanced Manufacturing Technologies.

	Strongly agree	Agree	Disagree	Strongly Disagree
Reduction in labour costs				
Superior image of firm				
Others - -				

4. Does volume flexibility drive your firm towards adopting **hardware equipment** related to Advanced Manufacturing Technologies?

	Strongly agree	Agree	Disagree	Strongly Disagree
Volume flexibility as opposed to delivery flexibility				

5. Collaboration with the following firms and institutions is considered vital to the adoption of **hardware equipment** related to Advanced Manufacturing Technologies.

	Strongly agree	Agree	Disagree	Strongly Disagree
Local firms*				
Foreign firms				
Higher institutions of learning*				

6. The following are considered strong deterrents towards the adoption of **hardware equipment** related to Advanced Manufacturing Technologies.

	Agree	Disagree
Lack of technical support		
Labour resistance		
Others - -		

Computer Software

7. The levels of education of the following categories of employees are considered very instrumental in the acquisition and/or use of **computer software** in your firm.

	Strongly agree	Agree	Disagree	Strongly Disagree
Functional Managers				
Engineers				
Others - -				

8. The following individuals, departments and factors are considered to have a positive influence in your firm towards the adoption of **computer software**.

	Strongly agree	Agree	Disagree	Strongly Disagree
Managing Director/CEO				
Engineering/Production Department(s)				
Environmental and health issues				
<u>Others</u> - -				

9. The following strategic motivation is considered to have a positive impact in your firm towards the adoption of **computer software**.

	Strongly agree	Agree	Disagree	Strongly Disagree
Superior image of firm				
<u>Others</u> - -				

10. Collaboration with the following firms and institutions is considered vital to their adoption of **computer software** related to Advanced Manufacturing Technologies.

	Strongly agree	Agree	Disagree	Strongly Disagree
Local firms				
Foreign firms				
Higher institutions of learning*				

11. The following are considered strong deterrents towards the adoption of **computer software** related to Advanced Manufacturing Technologies.

	Agree	Disagree
Lack of technical support		
Lack of confidence in AMT's		
<u>Others</u> **-** **-**		

<u>Integration efforts</u>

12. In your opinion the levels of education of the following categories of employees would be very instrumental in **integrating** (or linking) computer software to hardware equipment in your firm.

	Strongly agree	Agree	Disagree	Strongly Disagree
Clerical employees				
Secretaries				
Blue collar workers				
<u>Others</u> **-** **-**				

13. The following individuals, departments and factors are considered to have a positive influence in your firm towards the **integration** of computer software to hardware equipment.

	Strongly agree	Agree	Disagree	Strongly Disagree
Managing Director/CEO				
Marketing/Sales Departments				
Customers				

Tax incentives/Favourable financing				
<u>Others</u> **-**				

14. The following strategic motivations are considered to have a positive impact in your firm towards the **integration** of computer software to hardware equipment.

	Strongly agree	**Agree**	**Disagree**	**Strongly Disagree**
Increased domestic market share				
Increased foreign market share*				
<u>Others</u> **-** **-**				

15. The following manufacturing industries seem to have adopted more Advanced Manufacturing Technologies (AMT's) than the metal industries in Uganda.

	Strongly agree	**Agree**	**Disagree**	**Strongly Disagree**
Tea industry				
Bakery industry				
Dairy industry				
Alcohol industry				
Soft drinks industry				