FACTORS THAT DETERMINE THE PERFORMANCE OF TECHNOLOGY – BASED FIRMS IN KENYA.

BY

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DECLARATION

This thesis is my original work and has not been presented for the award of a degree in any other university.

Sign…… Date **……..**

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DEDICATION

This Thesis is dedicated to my late mother Joanina Stephen, my wife Hellen and my lovely children Fidella, Collins and Fiona. To them all, I say may you live to fulfill your champagne wishes and caviar dreams.

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LIST OF ABBREVIATIONS

ADB	African Development bank
BDS	Business Development Services
CIS2	Second Community Innovation Survey
ESRC)	Economic and Social Research Council
GDP	Gross Domestic Product
GNI	Gross National Income
GoK	Government of Kenya
ICT	Information and Communication Technology
ISIC	International Standard Industrial Classification Code
KNBS	Kenya National Bureau of Statistics
KAM	Kenya Association of Manufacturers
TBFs	Technology-Based firms
MNCs	Multinational Companies
MP&ND	Department of Ministry of Planning and National Development
MSIP	Monthly Survey of Industrial Production
NICs	Newly Industrialized Countries
NDI	National Directory of Industries
OECD	Organization for Economic Cooperation and Development
UNU-INTECH	United Nations Institute for New Technologies
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organization
R&D	Research and Development
RICyT	Ibero-American/Inter-American Network of Science and Technology Indicators
SIC	Standard Industrial Classification Code
SMEs	Small and Medium Enterprises
SPSS	Statistical Package for Social Sciences
S&T	Science and Technology
STI	Science Technology and Innovation
TBF	Technology-based firm
TBFs	Technology-Based Firms
WEF	World Economic Forum

OPERATIONAL DEFINITION OF TERMS

Technology-based firms (TBFs): Businesses whose products or services depend largely on the application of scientific or technological knowledge, or as businesses whose activities embrace a significant technology component as a major source of competitive advantage.

Performance: In these study performance is defined as a process that starts with investment in internal and external knowledge, transformation of the knowledge into commercial innovations that in turn is supposed to lead to increased productivity or more generally, economic performance of the firms.

Innovation activities: Activities that include all the scientific, technological and other developments performed in a firm, including investment in new knowledge, which are intended to, or in practice do, lead to the implementation of technologically new or improved products or processes.

Innovation: A new or significantly improved product (goods) introduced to the market, or the introduction within a company of a new or significantly improved process.

Innovative firm: This concept is applied to firms that have succeeded in turning innovative activities into effective innovations; i.e. has introduced product or process innovation.

Innovative capability: Capability of the firms consisting of the skills, knowledge and resources that enables them to assimilate, change and create technology.

Product innovation: A good or service which is either new or significantly improved with respect to its fundamental characteristics, technical specifications, incorporated software or other immaterial components, intended uses, or user friendliness.

Process innovation: A new and/or significantly improved production technology or new and significantly improved method of delivering products that is not necessarily new to the company or developed by that company or by another company.

Technology Acquisition: Adoption of external technology in embodied and disembodied form, where embodied technology comprises of machinery and equipment with improved technological performance connected to product or process innovations implemented by the firm while disembodied technology includes the acquisition of external technology in the form of patents, non-patented inventions, licenses, disclosures of know-how, trademarks, designs, patterns and computer and other scientific and technical services related to the implementation of product or process innovations.

Human capital: Used in this study to include skills of workforce and managers generated by formal education and training and those created by on-the-job training and experience of technological activity.

Social capital: The set of resources tangible or intangible that accrue to a firm through the firm's social networks or formal interactions with other firms and institutions.

ABSTRACT

This study aimed to investigate, in a knowledge based framework, the determinants of performance of Kenyan technology-based firms focusing on the role of human capital, social capital and traditional firm-level characteristics on firm new knowledge acquisition through R&D and technology acquisition (innovation inputs) and the transformational process leading to innovation output and firm performance. The empirical analysis focused on a sub-sample of 320 high and medium-high technology firms drawn randomly from a population of 772 firms located in Nairobi. The sample population was stratified using seven technology-based industrial sectors and three employment size bands. Data collection was done using a self-administered structured questionnaire and analysis done using SPSS version 11.5. The innovative capability was analyzed by use of descriptive statistics while the relationship linking investment in new knowledge, innovation and productivity was established by separately modeling the determinants of technology acquisition, R&D, innovation output and firm productivity. The study employed logit analysis for R&D decision and innovation outcome, probit analysis for technology acquisition, Tobit for R&D intensity and augmented Cobb Douglass production function for productivity. Empirical evidence revealed that the firm's innovations were largely incremental and that the innovative capability of the firms was largely inadequate. The results demonstrated that size and exporting variables were significant predictors of R&D decision, technology acquisition, innovation output and firm economic performance but not R&D intensity. Of the two innovation inputs, only technology acquisition increased probability of introducing innovations. On the other, hand innovation output contributed significantly to increased firm performance as measured in terms of value-added. Human capital variables had significant positive effect on all the dimensions under study while the role of social capital was multifaceted in its effect. While general linkages with competitors and other institutions had significant influence on the firms to invest in new knowledge, only linkages with customers had significant positive effects on the likelihood of the firms to innovate. On the productivity side linkages with competitors joined linkages with customers in increasing valued added. Lastly the following conclusions can be drawn: First, it appears that R&D directly contributed to higher firm performance during the study period by increasing the 'absorptive capacity' and not indirectly through innovation propagation as the main hypothesis posited, at least for Kenyan technology-based firms. Thus policies geared towards increasing the capability to transform R&D activities into commercial innovations would significantly increase the innovative performance of the firms. Second, since exporting large firms that had higher level of scientific and technical workforce and qualified managers, had cooperated with customers and competitors, had invested in R&D activities and technology acquisition and had launched new or improved products/processes to the markets performed better than those that did not, public policies meant to stimulate increased firm growth and export promotion; deepening access to qualified human resources; promotion of linkages between firms and other institutions; promotion of in-house R&D and external acquisition of technology in both embodied and disembodied form; should have positive results in terms of the overall performance of the firms.

CHAPTER ONE: INTRODUCTION

1.1 Background

For many decades developing countries have focused their attention to traditional industrial sectors such as agriculture, textiles and wood products as a means of employment creation, poverty alleviation, industrial modernization and economic growth. However, despite the increasing role these sectors have played in international trade, production and investment, most of the developing countries, particularly in sub-Saharan Africa still lag behind in meeting their industrialization targets, are technologically behind and poor. Consequently, developing country governments have recently shifted attention to techno-entrepreneurship (technology-based businesses) as a means of attaining the economic regeneration that has not been attained over decades despite the global performance of the traditional industrial sectors that characterize their economies. Technology-based enterprises have well-positioned several economies world-wide, competing effectively on innovativeness and strong performance, with potential to increase the number of start-ups, create jobs and to revive stagnant industries, (Audretsch, 1998). However, these firms that rely on significant application of scientific and technological knowledge to gain competitive advantage (Kodama, 1991), face intense pressure to innovate and to perform due to high risk of failure, global competition, fast changing technology and rapid product obsolescence (Oerlemans et al. 2001b).

In Kenya, the importance of technology-based firms (TBFs) as agents of industrial transformation and economic regeneration have recently received special attention in the country's Vision 2030 strategy document that aims to transform the country to a medium income economy by the year 2030 (GoK, 2008). In the Vision, the Government projects

that by 2012, total public sector investment will have risen to over 30 percent of GDP, buttressed by a substantial exploitation of knowledge in science, technology and innovation (STI). However, whereas the country expects these firms to play a central role in employment, industrial transformation and poverty reduction, the competitiveness and growth prospects of the firms fall below the levels required to meet the challenges posed by these expectations. This is because, despite the fact that TBFs such as pharmaceuticals, chemicals, electrical and electronics, have existed in the country for decades, their performance in the world stage has been progressively declining (ADB, 2008).

According to WEF (2004), the share of Kenyan innovative exports (technology-based manufactures) is only 4% of its national export volume which is three times less than comparable low income country like Indonesia. This indicates that, despite the theoretical importance, Kenyan technology-based firms are less internationally competitive which means the existing business environment, has not been able to shift the performance frontier. For these enterprises to respond to greater global imperatives and challenges to compete effectively in the local and global markets there is the need to understand the key factors that determine their performance in order to provide a solid basis for designing an effective public assistance infrastructure meant to enhance their competitiveness.

Many scholars agree that the performance of TBFs is increasingly knowledge based (Pakes & Griliches 1984; Oerlemans et al. 2001b, Kesidou, 2009). The performance of

TBFs is a process that starts with investment in knowledge and transformation of that knowledge into innovation output that in turn is expected to increase the economic performance of the firm (Polcuch, 2005; Knell et. al., 2008; Juma et. al., 2005). Internal technological efforts through R&D and external efforts through technology acquisition are taken as inputs into the innovation process that if transformed into innovation output would complement the investment in capital and ordinary labour to enhance the ability of the firms to increase their economic performance through increased productivity (Griliches, 1988; Romer, 1990; Van Reenen, 1997). The heterogeneity of performance of TBFs is thus, attributed to differences in the innovative capability that prevents them from investing in new knowledge through R&D and technology acquisition (innovation inputs) and to transform those inputs into innovative outputs that would capture specialized niches in international markets (Kathleen, 2003). The capability to engage in R&D and technology acquisition depends on a number of internal and external factors/inputs. Identifying the main factors that allow firms to generate new knowledge and the factors that enhance their ability to innovate and absorb new knowledge is of great importance for policy (OECD, 2005), especially within the developing country. Thus to establish the factors that enhance the innovative capability to invest in new knowledge and transform the new knowledge into commercial innovations, would be a necessary step in disentangling the determinants of performance of TBFs in Kenya.

Human capital and social capital factors and other internal organizational resources are argued to be crucial in the build-up of capability to generate and use new knowledge. Developing and use of technology requires skills and competences. Proponents of firm and industrial competitiveness argue profoundly that in order to survive global

competition, firms require the ability to create new knowledge or to use knowledge created elsewhere, which requires tremendous investment in human capital (Best, 2001; Mytelka, 2000). It is argued that conscious accumulation of human capital has enabled Newly Developed Countries (NICs) to acquire the necessary capability and innovative capacity, which has greatly enhanced their value, added manufacturing activities enabling them to participate competitively in the international export markets (Gachino, 2005). This study shall investigate the impact of human capital in determining the performance of TBFs in Kenya through its effect in fueling the innovation inputs and outputs of the firms.

With regard to social capital factors it is argued that networks with other firms and institutions like suppliers, customers, universities, provide external resources and capabilities into the innovation process which the firm itself cannot (easily) provide (Lundvall, 1988). The development of new and improved products requires an active co-operation involving several firms and institutions to tap new sources of knowledge and technology (Nooteboom, 1999; von Hippel, 1988). The Asian Tigers (Malaysia, Singapore, Taiwan and others) have tapped heavily from universities and firms to develop enviable stocks of scientific and technological (S&T) manpower that has enhanced technological and innovative capability. Rapid acquisition of in-house R&D capability by firms in these countries have permitted the latter to connect effectively with the global production networking of the multinational companies (MNCs) in many instances able to forge strategic R&D alliances with the MNCs.

Organizational resources represented by firm-level characteristics such as age, size and market orientation may affect the capabilities to invest into knew knowledge acquisition, the capability to transform the inputs into commercial innovation outputs and performance as they determine the availability of resources and firm - level competencies (Porter & Stern, 2002).

While there exists knowledge based empirical evidence that explains performance of TBFs in developed countries (see Griliches, 1979; Crepon et.al., 1998; Loof & Hesmati, 2002, 2006), few studies have explicitly established the relationships between investment in knowledge, innovation and firm performance in developing countries (Bala-Subrahmanya, 2005; Kesidou & Romijn, 2007, 2009). The study, carried out by Biggs et.al (1995) is one of the first systematic attempts to assess technological capabilities and firm performance in sub-Saharan Africa. Nonetheless, the study did not consider the technology-based sectors of the three countries studied (Kenya, Zimbabwe and Ghana). The study also considered technological capabilities and did not shed light on the specific issue of firms' capability to carry out innovations. Similarly, the recent studies on competitiveness of Kenyan manufacturing firms by World Bank have not shed light on the individual efforts of the firm to build up technological competencies as the studies focused on investment climate and other institutional factors that are beyond the control of the firm (World Bank, 2005; 2008a). Thus, empirically, it remains an open question how important different firm internal and external inputs are for explaining the innovation capability of technology-based firms in Kenya, and what knowledge based factors are important in stimulating the performance these firms.

1.2 Statement of research problem

In recent years, Kenya has shown interest in technology-based business as a means to attaining its vision of becoming a medium income country by the year 2030 (Republic of Kenya, 2008). However, despite the emerging interest, technology-based firms in Kenya are less internationally competitive (ADB, 2008) which means the existing business environment, has not been able to shift the performance frontier. For these enterprises to respond to greater global imperatives and challenges to compete effectively in the local and global markets and play their envisaged role in the vision there is the need to establish the key factors that determine their performance in order to provide a solid basis for designing an effective public assistance infrastructure meant to enhance their competitiveness.

From the background, it is clear that the performance of TBFs is a process that starts with investment in knowledge through R&D and technology acquisition (innovation inputs) and transformation of these inputs into innovation output that in turn is expected to increase the economic performance of the firm, that is, the performance is knowledge based. The background indicate that internal resources relating to human capital and organizational resources as proxied by firm specific characteristics as while as external resources relating to social capital provide the necessary resources and capability to engage in innovation input activities and to transform the inputs into commercial innovations. In developed countries, the impacts of these factors on investment in new knowledge, innovation and firm performance have been studied along with other factors in a knowledge-based framework. Empirical evidence covering innovation activities and

innovative capability building mechanisms that affect performance of industrial firms in advanced economies has lead to the design of policies that have boosted their global performance. On the contrary, empirical studies tailored to technological and social-economic uniqueness of developing countries like Kenya, that could be used for policy formulation to enhance the performance of the firms are lacking (Kesidou & Szirmaib, 2008). Thus, there is lack of knowledge on how the dynamics of complex interaction of internal and external inputs to the innovation process, whether deployed collectively or individually, are for explaining the performance of technology-based businesses in Kenya. This study contended that in order to establish the determinants of performance of technology-based firms in Kenya, it is important to investigate to what extend the differences in a firm's capability to invest in innovation inputs (R&D and technology acquisition), transform the innovation input into innovation output, and the relative performance of rival firms reflect underlying differences in human capital, social capital and other organizational resources at the disposal of the firm.

1.3. Main objective

The main objective of this study was to establish the determinants of performance of technology-based firms in Kenya by investigating the influence of technological business practices, human capital, social capital and firm-level characteristics on their innovative capability and ultimately by modeling the relationship between investment in new knowledge through R&D and technology acquisition, innovation and performance at firm level. It was aimed at broadening the understanding of technological behaviour of TBFs in Kenya and the channels linking investment in knowledge and innovation to

performance, fundamentally meant to provide empirical basis for the design of policies meant to strengthen their international competitiveness.

1.3.1 Specific objectives

Drawn from the main objective, the specific objectives were to:

a) Examine the business practices that reflect innovative capability of technology-based firms in Kenya.
b) Establish the human capital, social capital and firm specific factors that determine investment in innovation input activities by TBFs in Kenya.
c) Establish whether innovation inputs along with human capital, social capital and firm-specific characteristics determine the innovation output of TBFs in Kenya.
d) Investigate the relationship between innovation inputs, innovation output and performance of TBFs in Kenya firms.

1.4 Research questions

Drawn from the above objectives, the study sought to answer the following questions:

a) What business practices reflect innovative capability of technology-based firms in Kenya?
b) Do human capital, social capital and firm specific characteristics determine investments in innovation inputs by TBFs in Kenya?

c) What is the effect of investment in innovation input, human capital, social capital and firm specific characteristics on innovation output of TBFs in Kenya?

d) How is the relationship between innovation inputs, innovation output and performance of TBFs in Kenya?

1.5 Significance of the study

This study is significant on a number of grounds. First, whereas Kenya expects TBFs to play a central role in employment, industrial transformation and poverty reduction, the competitiveness and growth prospects of TBFs fall below the levels required to meet challenges posed by these expectations. Further challenges posed by globalization and liberalization suggest that TBFs must be internally and internationally competitive to survive and grow (UNIDO, 2002). The ability to create, distribute and exploit knowledge has become a major source of competitive advantage and firm performance. In a market-oriented environment, one way of achieving and maintaining competitiveness is by creating knowledge and transforming the knowledge into innovative outputs faster than competitors (Albu, 1997; Maskell & Malmberg, 1999)—all coming through the innovative capability of the firms. Thus the findings on innovation capability of the firms and the relationship between investment in knowledge, innovation and productivity provides helpful empirical information to aid the government and other development agencies to target firm-level assistance infrastructure towards increasing the performance of TBFs by fueling the innovation process. The study sheds more light on the role of social capital and human capital factors in the innovation input-output-productivity nexus

and advocate for their inclusion in designing and implementing an appropriate policy reform to stimulate increased performance in echnology- based sectors of the economy.

Second, the study enhances the understanding of techno-entrepreneurship in an African context. Much of the available literature is based on U.S.A and European experience, which may have little relevance in Kenya because of different technological endowments and different framework conditions. The research therefore contributes to knowledge and more understanding on how contextual factors of social capital, human capital and technological innovation influences techno-entrepreneurship in Kenya. This is of great benefit to scholars and students of entrepreneurship in various learning institutions and research centers both locally and abroad.

Third, the study is extremely helpful to the technology-based firms as it provides the parameters that would allow them to compare their technological conduct in defining strategies**.** The findings of the study identify weak and strong predictors of firm performance which when addressed can enhance the international competitiveness of TBFs in Kenya.

1.6 Scope of and limitations of the study

Study was limited to only product and process innovation. Organizational, marketing, and managerial innovations were not part of this study. The study laid special emphasis on technological, human capital, social capital, and organizational dimensions that affect the performance of TBFs. Institutional, social-cultural, political factors etc are beyond the scope of the study. The resources at the disposal of the researcher limited the study locale

to Nairobi which may have created sample bias. However, since Nairobi province has the highest concentration of technology-based enterprises compared to the distribution in the official statistics, the findings of this study can be generalized to technology-based firms in Kenya.

Another limitation associated with this study was with regard to capturing informal innovation activities particularly with regard to SMEs. SMEs are characterized by informal R&D that cannot be measured by the value of R&D investments or the number of research personnel (Crepon et. al., 1998; Kleinknecht & Reijnen, 1992). Similarly, the same firms often make expenditures in informal innovation activities that are hard to estimate since the firms may not know the monetary or labour resources assigned to these activities (Brissola & Quadros 2002). While these informal activities are very relevant, to developing countries like Kenya, a large part of them was not captured in the survey. Thus it was not possible to take into account their impact in the econometric analyses.

Lastly, the measurement of the firms' innovative activity expenditure and economic performance entailed significant difficulties. The main problems were linked to the difficulties faced by firms in answering quantitative questions due to poor record keeping and especially if questions involved accessing data from earlier financial years in order to record variable evolution or make temporal comparisons . Some firms were also reluctant to disclose financial information citing competition and confidentiality concerns. Despite attempts to collect quantitative data on firms' performance to the one that safeguarded

operational simplicity and fluidity of the measurement exercise, there were still many missing values particularly from SMEs. This problem limited the comparison of performance data between large firms and the SMEs. This calls for caution on the interpretation of the size variable that has proved significant in almost all the models developed in this study.

1.7 Assumptions of the study

The assumptions taken into consideration during the study were: First, that the respondents kept reliable business records with adequate detail. Second, the respondents provided true and honest answers to the items in the questionnaire. Third, that the three years period used for collecting innovation data was adequate to convert new knowledge into innovation output. Fourth, that the technological opportunity of firms in Nairobi was similar to that of the firms located in the other parts of the country. Fifth, it was assumed that the econometric estimations were not subject to sample selection (attrition) issues that would arise if the reported data were not representative of the population of the firms.

1.8 Chapter Summary

The chapter has given a succinct background of the problem highlighting the role technology-based businesses played in industrialization of developed countries and Asian tigers. It traces the drivers of superior performance of businesses in these countries to the ability to acquire new knowledge and to transform the new knowledge into innovation outputs that places the firms a head of competition. Sources of technological capability to

invest in innovation inputs were identified as human capital, social capital and organizational resources represented by individual firm-level characteristics. Experiences in these countries were contextualized to provide the theoretical underpinnings to guide investigation into the determinants of performance of TBFs in Kenya.

The rest of the Thesis is organized as follows: Chapter 3 presents a review of related literature with emphasis on the determinants of R&D, innovation and firm performance. Two theoretical perspectives - resource-based view of the firm and social capital theory guided the critical review of the literature that was pertinent to this study. Chapter 4 presents the results and discussion of findings while chapter 5 concludes the thesis by presenting the summary of findings, conclusions and recommendations drawn out of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The chapter provides a comprehensive review of literature relevant to understanding the drivers of performance of technology-based firms. It describes the characteristics of technology-based firm culminating in identifying the criteria used to identify technology-based firms in Kenya. It identifies pertinent issues for studying the performance of TBFs in developing country context and discusses the theoretical perspectives relevant to the study. Resource-based view of the firm and social capital perspectives among others are used to identify the factors that are relevant to innovation input-output-performance relationships. A summary is presented leading to the establishment of the research gap identified from the extant literature. The two theoretical perspectives together with knowledge production function and theory of absorptive capacity are tied together to develop the conceptual model representing a composite framework of factors relevant in influencing the performance of technology-based firms in Kenya. Lastly, a brief on the novelty of this study is presented.

2.2 Characteristics of the technology-based firm

Technology-based firms (TBFs) also known as innovative enterprises are businesses whose products or services depend largely on the application of scientific or technological knowledge, or as businesses whose activities embrace a significant technology component as a major source of competitive advantage (OECD, 1994). It must be implicitly assumed that the definition of precisely what constitutes high technology is meaningful in terms of the policies, which employ it. A consideration of the

various definitions of high technology used by either the academics or practitioners reveal that the issue is problematic. So far, there is no agreed definition and particular applications usually have recourse to a subjective and pragmatic classification at varying levels of industrial disaggregation (Neil et. al., 1990). As will be seen in the next sections, several definitions and classification criteria were used to identify the technology-based firms in Kenya.

Harris & McArthur (1985) have identified three approaches to the definition of high technology: purely subjective, drawing a distinction between product and process innovation and using surrogate measures of innovativeness. Most commonly found are those definitions in the latter category. They typically assume that high technology is related to research and development (R&D) effort. Ellin & Gillispie (1993) used both R&D expenditure and the proportion of scientists and technologists as a surrogate for those who employed in R&D to define high technology. These criteria gave rise to a slightly broader spread of industries than usually included in more subjective classifications, although the authors were constrained by data availability.

Weiss (1995) has argued that it is often the assumption that high technology industries are associated with only R&D, but also a high growth in output of sales, yet this can be true of industries that that are not considered as high technology. Alternatively, the emphasis may be placed upon employment growth or employment composition, which, it is suggested, is also unreliable indicator (Langridge, 1984). The consequence of using sectoral indicators is that they give rise to a definition of high technology that is product

based while ignoring the process innovation involved. Similarly definitions that concentrate upon production in the 'new' technologies such microelectronics fail to acknowledge that much of their impact will be felt as inputs to the production of other products, many of which fall within what are traditionally low-technology sectors (Freeman, 1985).

A commonly used approach to identifying high technology industries focuses on whether developing or applying new technological knowledge plays an integral role in the competitive strategy of the firm. Using this approach, a firm would be classified as technology-based if one of its primary assets was the possession of advanced technological knowledge used to develop new products or processes. While this definition is useful as a starting point, technological knowledge is an intangible asset that is not as readily measured, as are tangible assets such as plant and equipment. There are, however, several ways of quantifying the extent of a firm's involvement in the development of new products and processes. Firms have been considered technology-based on the basis of: (i) the extent of technology embodied in products and production processes; (ii) the determination that certain types of firms produce disproportionately more innovative outputs than others; and, (iii) relative expenditures on innovative inputs, such as scientific and technical workers, and especially R&D expenditures (Cordes et. al., 1986).

Charles River Associates (1976) proposed six criteria for distinguishing between technology-based and non-technology-based firms that combine the above elements. The

criteria were: (i) the degree to which a product is proprietary; (ii) how recently the underlying technology was developed; (iii) the extent to which a new market is created or an existing market is substantially transformed; (iv) the extent to which a product was based on scientific research; (v) rapidity of technological obsolescence; and (vi) the size of R&D expenditures required to develop a product. Twenty-four digits SIC code industries were found to satisfy all six criteria. They clustered in the broad industrial groups of electrical equipment, electronic components, chemical and allied products (including Pharmaceuticals), professional and scientific instruments, and aircraft and missiles and the criteria is useful in identifying technology-based firms in Kenya. The national industrial sectoral classification has electrical and electronics, chemical and allied, and pharmaceuticals sub-sectors (KAM, 2005). Thus this classification criterion is useful in identifying technology-based sectors of the Kenyan economy.

The Organization for Economic Cooperation and Development (OECD, 1994) has proposed a definition of a technology-based industry to be applied across all major industrialized countries. The classification was established in 1986 and is based on R&D intensities as measured by R&D expenditures as a percentage of production. Using this criterion seven industries were classified as high technology to low technology: Aircraft (aerospace), office and computing equipment, communication equipment, pharmaceuticals, petrochemicals, scientific instruments and electrical machinery were identified as high-technology while auto and auto parts, plastics were classified as medium-high technology sectors. While this definition was only developed to be applied in industrialized countries, it is also useful in identifying technology-based industries in

Kenya. Using this definition, plastics and auto and auto parts becomes industries of interest in this study.

2.2.1 Technology-based firms in developing countries

The approaches summarized above tend to equate high technology exports with the propensity of a firm to invest in research and development in order to create and apply advanced technological knowledge for product and process innovations. Yet, economists have come to recognize the importance of diffusion of new technologies, products, and processes as well as their creation (Cordes et. al., 1986). An important source of such diffusion is the use of capital equipment that embodies technological advances. Some firms are likely to play a significant role in the overall diffusion of new technologies as users of new products or processes, even though such firms are not regularly engaged in the initial development of such new products or processes. A good case can be made that firms who make regular use of new technologies to produce their goods or deliver their services should also be considered as part of the high technology sector of the economy, in addition to firms that develops such technologies. The list of technology-based industries that are broadly consistent with this more expansive definition of what constitutes technology-based businesses was developed by Lall Sanjay (2000) and extends OECD (1994) classification to take into account product clusters of interest to developing world. The list of industries according to OECD and that of Lall Sanjay are presented in appendix C and is used to identify the technology-based industrial sectors in Kenya. Generally, the OECD and Lall classification among the other classification criteria discussed in this part of the literature identifies technology-based firm in Kenya

to comprise of pharmaceuticals, electrical and electronics, medical precision and optical instruments, plastics, chemical and metals and machinery, and auto and auto parts. These are the industrial sectors that formed the subjects of investigation in this study.

2.3 Resource-based view of the firm and social capital theory

What determines the performance of technology-based businesses is a perennial research question for organizational scholars. Numerous perspectives have been developed to explain performance differentials. This study invokes firm-level theories to account for the variation in performance among technology-based firms. The resource-based view of the firm and social capital theory attributes superior firm performance to its internal organizational resources or/and capabilities and its relational characteristics with external entities (Grant, 1991). Within the theoretical framework, the literature suggests that idiosyncratic internal and external resources define a durable competitive advantage. Intangible factors such as human capital (Barney, 1991) innovation and technological resources (Hadjimanolis, (2000) financial resources (Martin, 2001) social capital (Porter, 1992) among others are elements that clearly contribute to build-up of innovative capability which is key to the success of technology-based enterprises (Lee et. al., 2001). The capabilities literature extends the RBV with the proviso that in order to achieve superior performance; the focal firm not only needs to secure idiosyncratic resources but also needs to develop corresponding capabilities (Eisenhardt & Martin, 2000). The capabilities of technology-based ventures are embodied in the application of science and technology. TBFs create innovative capability by perceiving or discovering new and better ways to compete in an industry and bringing them to market, which is ultimately an

act of innovation. TBFs make these discoveries by engaging in internal efforts (in investing in in-house R&D) or external efforts (technology acquisition) to generate knowledge that is used to develop new products or new processes (innovations). Thus the capability of the firm to engage in R&D activities and technology acquisition determines the innovativeness of the firm which in turn is expected to boost its performance. Innovation is a resource and capability of the firm and the most prominent driver of performance of innovative enterprises (Barney, 1986; Hall, 1991; Prahalad & Hamel, 1990). Social capital factors which include, interaction with suppliers, customers, public agencies, and industry associations, provide missing inputs into the build-up of innovation capability which the firm itself cannot (easily) provide (Lundvall, 1988). Using this perspective this study focused on social capital variables to disentangle the external determinants of performance of TBFs in Kenya.

Thus, organizational resources and capabilities are taken to offer the necessary input for the development and exploitation of the firm's innovation activities, which in turn are expected to affect firm performance. Consequently, the focus of the RBV and social capital theory is not only on how to squeeze innovative output out of the organizations, but also on how to provide the fuel for innovative activity to occur in the first place (Benhabib & Spiegel, 1994). Using these two perspectives, this study identifies technological, human capital, social capital and organizational resources as the determinants of innovation capability that when employed individually or collectively affect the innovative outcome of the firm and hence its economic performance. The following literature attempts to summarize the empirical literature on determinants of

knowledge acquisition through R&D and technology acquisition and on firm-level innovation that are important in understanding the performance of TBFs. Prior to this, however, it may be useful to provide a sketch of technological capability and innovation process in developing countries.

2.4 The concept of technological capabilities and innovation in developing countries

There is a fairly widespread belief that technological innovation activities are concentrated in developed countries and their results the creation of technologies to be incorporated into' production capability' (the stock of capital goods and operating know-how required to manufacture the existing goods with productive efficiency). Developing countries there are only diffusion processes of the technologies from the developed countries. It is also believed that firms in developing countries are able to gain access to innovations, either free of charge or otherwise, but without difficulty assimilating them and putting them to efficient use (Crepon et. al., 1998).

On the basis of this analysis, the conclusion might be reached that the only indicators relevant to an assessment of the level of technological innovation in developing countries are imports of capital goods, direct foreign investment flow and disembodied technology transfer (licenses, know-how, and so on). However, the distinction between innovation and diffusion as two distinct activities taking place sequentially is a highly questionable one (López & Lugones, 1997). Though 'radical' innovations are unlikely to emerge in developing countries, empirical evidence reveals that technology diffusion involves continuous (generally incremental) technical change aimed at adapting acquired

technologies to the specific context of their application, and at attaining higher levels of operating efficiency. To raise efficiency or establish a better competitive position, firms' efforts are oriented towards developing capabilities to absorb, adapt and master technologies often developed elsewhere in a process of technological learning. Cohen & Levinthal (1989) developed the concept of 'learning' or 'absorptive' capacity to refer to firm's capabilities to identify, assimilate and exploit externally available information. Such activities are important for at least two reasons: i) through the accumulation of minor innovations, significant productivity increases can be realized and ii) because of differences in resource endowment, input type and quality, local tastes, and so on, it is always necessary to adapt imported technologies for their use in the local environment. It is for this reason that investment in technology acquisition was taken as innovation input into the innovation process that is crucial in determining the performance of TBFs in Kenya. Majority of TBFs in developing countries realize productivity gains by undertaking efforts that bring them closer to the technological frontier, by absorbing and adapting externally developed knowledge, rather than from creating new knowledge within the firm. Given that Kenyan TBFs exist in a competitive context that is characterized by internationalization and globalization and conditions that are not propitious to organizing frontier type of R&D activities, it becomes important to analyze if technology acquisition influences their innovative capability and using the concept of absorptive capacity determine whether it has direct effect or indirect effect on the performance of the firms through innovation propagation.

The concept of innovation is accordingly a much broader one than ‘invention’, which focuses on novelty and is applicable to frontier shifting new knowledge. Instead, innovation refers to the application of knowledge that is new to the firm and not necessarily new to its competitors, the market or the world. It incorporates a broad set of activities that individual enterprises undertake to gradually absorb knowledge and build upon existing knowledge necessary for efficient production and higher quality output. Minor and incremental rather than radical changes are at the heart of this innovation process in developing countries.

This broader definition of innovation has given rise to a debate on how to measure innovation in developing country firms. In recent years, several initiatives have been undertaken to develop alternative measures of innovation activities and they stress the need to incorporate a larger set of activities that encompass learning in firms than what is needed for OECD country firms (OECD, 2003, UNU/INTECH, 2004, OECD, 2005, Oslo Manual, see annex on innovation surveys in developing countries). Measurement priority is placed on mechanisms of knowledge diffusion which include human resources, linkages with other firms and non-firm organizations, the use of ICT, acquisition of embodied technology, and it should capture incremental improvement of existing technologies (minor innovations) as they are likely lead to significant growth in productivity in certain cases (Bisang, 1998). In consideration of these concerns, this study adopted the definition of innovation based on the Bogota manual (OECD, 2003) for innovation surveys in Caribbean and Latin America that included new or significantly improved products and processes that the firms implemented during the period 2004-

2006. By so dong, the study recognizes the importance of not only new technological developments by the firms, but also new combinations of existing technology, or utilization of other knowledge acquired by the firms.

2.5 Social capital theory and innovation

Recently, the systemic approach about innovation and the networks and inter-organizational approach have made progress in the field of innovation. Organizational networks have been investigated as a key factor that influences organizational actions and performance. The theoretical approach, developed in the scope of the innovation systems support the basic idea, that innovation is not an isolated action within the firm and it is not only dependent from the R&D intensity. Innovation is regarded as an evolutionary, non-linear, and interactive process between the firm and its environment (Kline & Rosenberg, 1986; Dosi et. al., 1988, Malecki, 1997). Interactivity of the innovation process refers to the collaboration amongst internal divisions of the firm (R&D, production, logistics, marketing, etc) as well as to the external relations that are established with other stakeholders (suppliers and customers), knowledge institutions (universities and technological centers), finance, and public administration. In this context a wide range of partners may contribute to acquire external resources, knowledge and crucial information for developing productive and innovative activities. Interaction between firms and other external agents is seen as a strategic mechanism to achieve several objectives (Cassiman, 2002; Hagedoorn, 2002 among others): 1) to increase the technological capabilities of the firm; 2) to gain access to new markets and to exploit new business opportunities; 3) to have access to public funding; and 4) to complete the

innovation process. In this study, the interaction of firms and other external agents was considered as a strategic mechanism to complete the innovation process.

These interactions may be the consequence of formal alliances and/or cooperation agreements or they may occur in a more informal way. In both cases, they usually entail some form of knowledge and/or information exchange between the partners involved. Knowledge acquired from either informal or formal external linkages differs on the form of access as well as on the content being transferred (Swann, 2002; Monjon and Waelbroeck, 2003). In particular, the use of informal sources of knowledge seem to be associated with the internal capabilities of firms to access and absorb the knowledge produced by other market or research actors more or less immediately. Instead, the knowledge derived from formal collaborations seems associated with the use of ideas and developments that result from the access to infrastructures, human capital, and innovative capabilities of partners. Besides the distinction between formal and informal external linkages, another important aspect is the issue of the specific role of the external sources of knowledge for the specific type of innovation which forms the basis of literature review in the next section.

2.5.1 Importance of partner diversity in the innovation-performance relationship

The types of partner firms engaged in networking appears to be related to the type of innovation occurring. Traditionally, the capability to translate external inputs of knowledge into successful innovations has been associated with the presence of high

absorptive capacity at the firm level (Cohen & Levinthal, 1989; Cohen et. al., 2002; Swann, 2002).

However, the capabilities required to successfully innovate may vary depending on the type of innovation that firms want to develop. Many empirical analyses have stressed that in order to pursue specific innovations strategies, firms are required to interact with specific actors. User-producer interaction, for instance, is widely acknowledged as crucial for product innovation (von Hippel, 1988). To develop and market a novel product innovation, getting knowledge and collaborating with customers is as important as performing internal R&D investments, since customers are an important source of information that may boost product innovation (Belderbos et. al., 2004). When product innovation is based on a recent scientific discovery, it often entails a formal collaboration with universities (Tether, 2002; Monjon & Waelbroeck, 2003). Firms that mainly pursue an imitation strategy instead seem to prefer horizontal technological information from competitors (Baldwin et. al., 2002; Cabagnols & Le Bas, 2002). Firms pursuing process innovation, which entails investments in machinery and equipment, seems to require mainly interaction with suppliers (Pavitt, 1984; Malerba, 1992). Similarly, Swann (2002) finds that British process innovators tend to use universities both as a knowledge source provider and R&D partners when compared to product innovators. Malerba (1992) further find that knowledge from suppliers enhance process innovations in firms with a cost-focus strategy, while the probability of doing process innovation is negatively associated to the use of customers as a source of knowledge.

The need to develop specific external linkages may also depend on the type of industry and technology (Pavitt, 1984; Marsili, 2001). Firms active in science-based industries generally tend to benefit most from interactions with public research organizations and focus on (novel) product innovation (Cabagnols & Le Bas, 2002; Leiponen, 2002; Belderbos et. al., 2004). In supplier-dominated industries, firms rely mainly on suppliers as source of process innovations (Leiponen, 2002). Specialized-suppliers rely mainly on customers as sources of information to develop customized product-innovation and solve technological problems to their clients (Riggs, & von Hippel, 1994). In scale-intensive activities, which are also high capital- intensive, firms achieve competitive advantage by exploiting economies of scale and firms tend to innovate more in product than in process (Martínez-Ros & Labeaga, 2002). Altogether, existing contributions hint at the following: engaging in a specific type of innovation strategy may require the integration of several specific types of knowledge and therefore firms need to interact with several actors at the same time. This study examined the importance of various actors (suppliers, customers, competitors and universities) in determining the capability of TBFs to invest in new knowledge; the ability to transform the new knowledge in innovation output; and the capacity to increase the performance of the firms.

It is also important to recognize that while networks play a crucial role promoting the development of innovations within and across firms they also play a key role in the diffusion of innovations across and within sectors. For example, at an institutional level, national systems of innovation do play an important role in the diffusion of innovations in terms of the way in which they shape networking activity (Nooteboom, 2000, Furtardo,

1997). Nooteboom's study (2000), for example, characterizes the UK innovation system as one that promotes the diffusion of more radical innovations which demand entrepreneurial activity cutting across sectors, rather than promoting the diffusion of innovation within sectors. This clearly has networking implications. At an organizational level, the involvement of managers and lower level employees in professional and industry linkages has been found to promote the diffusion of innovations (Robertson et.al., 1996). The more involvement individuals have in these forums the more likely it is that the firms in which they are employed will adopt new innovations. Most prior studies investigated the function of social capital in fueling the innovation process, but have not articulated its importance in the context of TBFs and their value creation in developing countries. This is a gap in relation to social capital that this study attempted to fill.

For the empirical analysis the theoretically expected effects of successful innovation networking on the innovation activities of firms can be summarized as follows: First, the adaptation of external resources within such collaborations leads to an extension of firms' technological capabilities to develop new and improved products. This becomes evident in an increase of technological know how and improved skills. Second, assets, resources and information transferred in networking relationships improve the research efficiency of the firms that raises the possibility of acquiring technology and attaining successful innovation outcomes. Such effects can be observed by higher rates of return of R&D with positive impacts on firms' innovation input, output and firm performance. Third, the type of partners networking efficiently with each other affects the efforts of firms to develop new products and processes positively and would give and indication of the type of

innovations launched by the firms. From the forgoing literature, this study considered a number of networking partners that would give an indication about the type of innovation outcome pursued by TBFs in Kenya. The study considered the propensity of the firms to partner with customers and competitors that indicates pursuit of incremental innovation; suppliers for major innovation; and universities for radical innovation.

2.6 Resource-based theory and innovation.

The resource-based research on innovation is based on the fundamental premise that organizational resources and capabilities are those that underlie and determine a firm's capacity for innovation. Within this perspective, organizational resources (tangible and intangible) are taken to provide the input that in turn is combined and transformed by capabilities to produce innovative forms of competitive advantage. As discussed in section 2.2.1, innovative capability of TBFs in developing countries is created through internal technological efforts involving innovative activities (mainly in-house R&D) and external efforts through acquisition of machinery and equipment embodied in the application science and technology. A firm which plans to invest in R&D or adopt a certain technology first evaluates the relative benefits and costs of investment in R&D or adoption and accordingly makes the decision to either invest in R&D or technology acquisition. Several factors influence the firms' evaluation of the returns from these activities. The characteristics of the firm, its internal resources to effectively engage in R&D activities or implement the acquired technology, its position in the market and so on are the crucial factors which go into the firms' evaluation of the returns from these innovative activities (Barney, 1986; Hall, 1991; Prahalad & Hamel, 1990). Carrying out

innovation activities in many cases requires a minimum prior investment in highly sophisticated technical equipment, which raises the possibility of producing innovative output of increased value for the firm (unique, diversified products) and for its customers (increased quality).

Research that is more recent has shifted attention from tangible to intangible resources. Intangible assets may be more important from a strategic point of view, since they bring together more frequently the requirements necessary for producing sustainable advantage: to be valuable, rare and difficult to imitate and replace by competitors (Barney, 1991; Lee et. al., 2001). For example, a high stock of qualified human capital with advanced technical skills and know-how in R&D projects increases the probability of a firm to carry out innovative activities (Barney, 1991). The resource-based research on innovation is based on the fundamental premise that organizational resources and capabilities are those that underlie and determine a firm's capacity for innovation. Within this perspective, organizational resources (internal and external) are taken to provide the input that in turn is combined and transformed by capabilities to produce innovative forms of competitive advantage (Prahalad & Hamel, 1990). Using this RBV perspective, this study investigated to what extend the differences in the capability to invest in new knowledge, the capacity to transform the new knowledge into innovation output, and the relative performance of TBFs reflected underlying differences in internal and external resources at the disposal of the firms.

2.7 Factors with potential impact on innovation-performance relationships

For the sake of convenience this study groups the potential factors which influence (positively or negatively) a firm's decision to engage in input activities to innovation into human capital, social capital and organizational resources. Empirical evidence of these factors into the build-up of innovative capability and innovation input-output and firm performance relationships is discussed below.

2.7.1 Firm characteristics and innovation

Economics of innovation emphasizes differences in firm's technological and organizational resources and competencies as the crux of difference in innovation abilities of the firms (e.g., Freeman, 1985). In the literature, firm size has been traditionally regarded as a crude measure for the extent to which a firm may be said to be resource-rich. The importance of firm size upon the innovation effort and its success for a firm has a long history and classical flavour to it (Schumpeter, 1942). It is argued that large firms have multiple production sites and a larger base of experience with various technologies that can help in engaging in R&D and the adoption of new process technologies. Moreover, established large firms have an advantage in the capital markets and therefore can marshal greater resources quickly than smaller firms in implementing R&D and adopting and implementing a new technology. Therefore, firm size can act as a major source of innovation capability through R&D and technology acquisition. In most of the studies on innovation capability, firm size often stands for many firm-specific effects (financial resources, range of activities) and /or functions as a proxy for other variables on the model when it is strongly correlated with them (size-dependent models).

In this study, the size variable was taken as a proxy to represent organizational resources that determine innovation inputs, innovation outputs and firm performance.

There are, however, a number of factors that suggest small firms may have an advantage. Small firms may be faster at recognizing opportunities. They may be more flexible with respect to adjusting research plans or in the implementation phase of innovations. Small firms may also find it easier to adjust employee incentives to provide optimal innovative effort, or allow less rigid management structures that allow key employees to devote time to innovation-related, not management-related, tasks. The findings from some data sets of innovations in the UK and the US suggest that smaller firms do have an advantage. Analysis on the ESRU major innovations data set for the UK, and the Small Business Administration major innovations data set in the US, showed that small firms have higher innovations per employee. However, Tether (1998) points out that the number of innovations is not the same as measuring the value of innovations. Hence, small firms might have more innovations per employee but the average value of each of these innovations may be lower than the innovations in large firms. Using ESRU data, Tether finds this is in fact the case.

Another related factor to organizational resources, firm age, has also been posited to be an important factor determining the decision to conduct R&D and to adopt new technologies. It is a variable commonly used to measure the experience and the learning of the firms in empirical studies of innovation (Kumar & Saqib, 1996). However, like other earlier studies have mentioned, the impact of firm age on technology acquisition is

difficult to predict a-priori because of the presence of two opposing effects (e.g., positive impact reflecting specific experience of old firms versus a negative effect due to lower adjustment costs in relatively new firms with a more modern capital stock besides the more openness of managers of newer firms towards new technologies. In this study age variable was used to determine whether there were differences in the capability to engage in innovation input activities and firm performance between new and old firms.

Another factor related to organizational resources is the role of foreign ownership in innovation. Numerous studies have recognized the effect of ownership structure on innovation, capturing its influence by focusing on foreign ownership (see Becheikh et. al., 2006). Some arguments suggest a positive influence (foreign ownership may imply greater financial resources or access to knowledge and technology), whereas a product life cycle view implies R&D and innovative activities are conducted close to home markets. Some recent empirical analysis for the UK has suggested foreign ownership has a negative association with measures of innovation capability (Love & Roper, 1999) although Love & Roper, (2001) find a positive relationship for a sample of Scottish manufacturing plants. For Australia, Ernst et.al, (1999) find that foreign ownership reduces the likelihood of process change in workplaces, with Rogers (1995) confirming this finding. Looking only at large firms in Australia, Bosworth & Rogers (1998) finds a negative association of foreign ownership and R&D intensity. Foreign-ownership in this study was investigated to determine whether its effect in fueling the innovation process and firm performance was also negative in the Kenyan context in line with these findings.

Export performance and innovation are likely to be inter-related. In general, innovative firms may seek to exploit overseas markets, suggesting that the causality runs from innovation to exports. Empirical studies have shown that this appears to be the case (Lefebvre et.al., 1998), although this work suggests a need to carefully control for both the nature of innovation and the type and destination of exports. However, it is also possible that firms that export also have access to improved knowledge flows and, possibly, higher incentives. Hobday (1995) suggests that the exporting activity of firms in SE Asia had a direct impact on their productivity and growth. He argues that knowledge of how to innovate was effectively passed to exporting firms from overseas markets. Moreover, exporting may also affect firm innovation output through learning.

A number of studies document a positive effect of exporting on innovation capability. Alvarez & Robertson (2004) for samples of Chilean and Mexican plants find a positive relationship between exporting and probability of innovating for various measures of innovation activities such as investments in improving the design, production processes, or product quality, the presence of R&D activities, and purchases of foreign technical licenses. Salomon & Shaver (2005), examining the effect of exports on the number of product innovations and patent applications, found that exporting is positively associated with the subsequent increase in the number of product innovations and the number of patent applications. In this study, export propensity, along with other factors was used to determine the heterogeneity of firm performance through disentangling its effect in the innovation input-output process.

2.7.2 Human capital and innovation

The firm's ability to absorb knowledge from external sources and use it in its innovative activities have been long associated with firm's innovativeness in general and technology adoption in particular (see Cohen and Levinthal, 1989). The owner and manager influence the firms to achieve resource accumulation and capability development in innovative firms. Concerns about technology sourcing, management stockholdings, firm risk orientation, and slack resource availability moderate the extent to which the perceived threat of opportunism, the threat of commercial failure and the opportunity for sustainable advantage all influence firm boundaries (Stuart & Abetti, 2001). In addition, integrating capabilities affect product efficiency and product effectiveness through the creation, the utilization, and the capitalization of capabilities (Archibugi & Coco, 2004).

A skilled and educated work force enhances the absorptive capability of a firm (Cohen and Levinthal, 1989). This is because the endowment of human and knowledge capital within a firm determines the firm's overall ability to assess technological opportunities in (or around) its fields of activity. The endowment of human capital can be proxied by the percentage of technical and managerial staff among the employees. The higher the proportion of trained engineers/scientists managerial employees, the greater is their ability to absorb the knowledge around them within and outside the firm. Therefore this variable is expected to be positively related to R&D and technology adoption.

The potential relationship between the extent and nature of training and innovation is another issue of importance related to human capital. Some authors have suggested that a

more highly trained workforce will have an advantage in developing, adopting and implementing new technologies (Kimuyu, 1999). Acemoglu (1999) finds, for example, that technical change has been skill-biased over the past 60 years. Firms with larger human knowledge bases (the number of employees dedicated to R&D), have higher performance levels. While strength in "high-tech" depends upon the availability of university trained people, industry more generally requires a supply of literate, numerically competent, people in a wide range of functions outside R&D' (Nelson 2000). Hatch & Dyer (2004) found that human resources are strategically important in semiconductor manufacturing as they embody firm-specific tacit knowledge and that firms that employ effective human resource selection, training and deployment process facilitating learning by doing, enjoy sustainable competitive advantage, (Hitt et, al. 2001). It is seen that it is vital to develop managerial competencies in the R&D department of firms, due to the increasing availability of innovative competencies on the market.

A crucial dimension associated with innovation capability through technological acquisition is R&D (Arvanitis & Hollenstein, 2001). Investment in R&D directly contributes to the absorptive capability of the firm, which increases the likelihood of adoption of advanced process technologies (Cohen and Levinthal, 1989). Intensity of investment in R&D was used as an explanatory variable in technology acquisition equation.

2.7.2.1 Role of human capital in transforming the economies of Newly Developed Countries

Over the past few decades the Newly Industrialized Countries (NICs) in East Asia were able to transform their economies from agriculture-dominant traditional economies to industry dominant modern economies by making tremendous progress in technological capability development (Kim, 1999; Westphal, 1990; 1994; Lall, 1992, 1996). Since human capital is the driving force behind technical progress, skill development and productivity in an industry, their success was largely attributed to its promotion and development in earnest. The government in the NICs played a significant facilitating role in human capital development (Fransman, 1988; Chang, 2003). It is argued that conscious accumulation of human capital has enabled these countries to acquire the necessary capability and innovative capacity, which has greatly enhanced their value, added manufacturing activities enabling them to participate competitively in the international export markets. Multiple examples can be cited ranging from automobile, shipbuilding, electronics, and textiles to semiconductors industries (Rasiah, 2000). Proponents of firm and industrial competitiveness argue profoundly that participation in international market requires tremendous investment in human capital in order to survive global competition (Mytelka, 2000). For this reason, human capital variables were a major focus in this study.

2.8 Innovation capability in Kenya

Innovation capabilities refer to “the firm’s current ability and its future potential to apply firm-specific technology to solve technical problems and/or enhance the technical

functioning of its production process and/or its finished products" (Nicholls-Nixon, 1995). Since innovation is a key source of growth and competitiveness (WEF, 2004), firms that are able to generate knowledge and transform it into innovative outputs have a better competitive edge over those that can not. The ability to use new technology is best captured by the production and investment capabilities whereas the ability to invent or innovate new technologies is captured by innovative capability (Romijn & Albu, 2001).

Technology indicators from WEF (2004) presented in Table 2.1 reveal that in terms of innovative capability, Kenya fairs worse than comparable best performers like South Africa, Singapore, Brazil, Mauritius, UK and USA.

Table 2.1: Indicators of innovative capability

	Kenya		Uganda		Tanzania		South Africa		Singapore		Brazil		Mauritius		UK		US	
	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S	R	S
Prevalence of technology licensing	18	5.3	17	5.3	31	5.1	22	5.1	1	6.3	42	4.9	50	4.7	19	5.3	78	4.3
Company Spending on R&D	32	3.7	38	3.4	69	2.9	24	4.0	9	4.8	31	3.7	50	3.1	11	4.7	2	5.8
University/Industry research collaboration	63	2.9	35	3.6	50	3.1	19	4.3	5	5.1	28	3.8	59	29	8	5.0	2	5.4
Quality of scientific research institutions	31	4.4	33	4.4	45	3.9	27	4.5	13	5.2	37	4.3	57	3.7	5	5.8	1	6.3
Availability of scientists and engineers	55	4.7	72	4.2	83	4.0	88	3.8	19	5.5	58	4.7	81	4.1	34	5.1	8	5.9
Utility patents, 2003	68	0.2	79	0.0	77	0.0	32	2.5	10	99.3	46	0.7	79	0.0	17	61.2	1	299
Capacity for innovation	66	2.9	62	30	95	2.4	2	3.5	18	4.6	37	3.7	59	3.1	10	5.4	7	5.8

Note: R stands for the rank of a country out of 104 countries while S stands for the score of the country within a range of 1 (the lowest) and 7 (the highest

Source: World economic forum (2004). World Competitive report 2004-2005

The statistics show that the country lags behind countries that have performed better in terms of technology effort undertaken by firms. Out of 104 countries, Kenya is ranked

67th in terms of the capacity for innovation with a score of 2.9 (which falls below the mean score of 3.5) (WEF, 2004). This implies that Kenya's capacity for innovation falls below the global average. It also fairs badly compared to Singapore though the two countries were at par in terms GND in 1960s.

This low capability for innovation is surprising considering that the country ranks quite high (position 32and 55) in terms of firm R&D spending and availability of scientists and engineers respectively, considered very vital in creating knew knowledge and transforming the new knowledge into innovative outputs (Polcuch, et.al., 2005). Similarly, the country appears to have competitive advantages in the areas of FDI-associated technology transfer, prevalence of foreign technology acquisition through licensing, and quality of scientific research institutions. Thus it can be argued that the probability of innovating by Kenyan firms relies more on external technological efforts through technology acquisition as an input to the innovation process than internal technological efforts which, was tested empirically in this study. Its direct and indirect effect in increasing firm performance using the theory of absorptive capacity was also examined.

2.9 Previous empirical studies on innovation and firm performance

The first study to empirically address the role of innovation for economic growth is Solow (1957). Solow uses a Cobb-Douglas production function and concludes that the traditional inputs of the production function, that is, labor and physical capital, only explain a fraction of economic growth. The remaining fraction would result from technological progress. This residual part is the so-called "Solow's residual". In the

decades that followed, many authors worked at decomposing this residual and finding a way to express technological progress as an explicit explicative variable of economic growth, and not only as a residual. A major contribution in this literature stream came from Grilliches (1988) who first proposed to proxy technological progress by R&D indicator and introduce it directly into the production function. This approach has then been further applied and elaborated by authors like Griliches (1979,), Hall & Mairesse (1995), and Del Monte & Papagani (2003). However, this approach has been questioned by scholars and for good reasons. R&D expenditures account for only a modest part of the total innovation input by the firm (Brouwer & Kleinknecht, 1997), and not all R&D investments lead to commercial innovations (OECD, 1997). Patents, most of all patent counts, have been seen as an option to get over this shortcoming, (Acs et al. 2002; Brouwer & Kleinknecht, 1999; Acs & Audretsch 1989; Griliches, 1984). However, patent–based indicators have been heavily criticized as being a poor indicator of innovative outcome (Griliches, 1990). Not all inventions are patented, and not all patented inventions lead to marketable innovations. For this reason, subjective measures that capture the introduction of innovations whether new to the firm, new to the industry or market were used in this study.

Parallel to the empirical research, based on Cobb-Douglas production function, another strand of studies has tried to estimate the link between R&D inputs and innovation outputs at the firm level, in terms of a knowledge or innovation production function, that explains the transformation of innovation input into innovation output, (Griliches, 1998). The knowledge production function relates R&D to patents, (Griliches, 1990) or R&D to

innovations, (Klinknecht & Mohnen, 2002). The Cobb-Douglas production functions, does not measure this relationship. The neglected link is what Pakes & Griliches (1984) label as 'the knowledge production function', i.e. production of commercially valuable knowledge or innovation output, (Loof & Heshmati 2002), and is represented as a set of three equations: i) the innovation input equation, ii) innovation output equation, and iii) productivity or more generally performance equation. The innovation output depends on the presence and volume of innovation resources, and the utilization of the internal and external resources, in the innovation process (Oerlemans et al 2001b; Freel 2005). This study applied the concepts of knowledge production function since it was interested in investigating the determinants of performance of TBFs in Kenya, by looking at sources of capability for the firms to invest in knowledge, and the ability to transform that knowledge into commercial innovations, that in turn was expected to affect the economic performance of the firms.

A considerable body of research has been developed, examining the link between innovation input, innovation output, and firm performance (Acs et al. 1994; Love & Roper 1999, 2001; Oerlermans et al 2001; Mairesse & Mohnen 2004). Conceptually, the authors present innovation as a process that starts with R&D and continues with the application of patents and the sale of new products. Empirically, they build a model that explains productivity by innovation output and innovation output by research investments or what is known the knowledge production function. Their results demonstrate that it is in fact innovation output that drives firm productivity, and not innovation input (R&D investments). But other researchers argue that the dual nature of R&D in creating new

knowledge and increasing absorptive capacity means that R&D activities can directly affect firm productivity. In other words R&D efforts do not necessary result in innovations successful to the market but can affect firm performance directly without occurrence of innovation (Cowan & van de Paal, 2000). The theory of absorptive capacity, argue that the key role played by R&D results from two effects. The first one is the development of innovations that R&D investments enable. The second one is the learning effect associated with the progressive development of a stock of knowledge at the origin of a firm's absorptive capacity (Cohen & Levinthal 1989). These contradictory arguments necessitated this study to investigate whether investment in knowledge affects firm performance directly or indirectly through the occurrence of innovation.

The literatures on absorptive capacities and technological capabilities have shown that the development of internal processes of learning within the firm is a prerequisite for the acquisition of technology and thus external knowledge. Purposeful investments in knowledge enable firms to select, adopt, modify and improve a new technology (Lall, 1992; Cohen and Levinthal, 1989; Romijn, 1999). It is a commonly held view that R&D and investments in machinery and equipment (technology acquisition) together with knowledge labour and ordinary labour makes a main contribution to firms' performance (Griliches, 1988; Romer, 1990; Van Reenen, 1997). Firms invest in knowledge and capital in order to enhance their competitiveness and capability to earn profits. Erickson & Pakes (1995) show that the stochastic outcome of a firm's own investments in R&D together with physical capital, human capital, social capital and the competitive pressure

from other firms within or outside the industry determine the sales performance, profitability and growth of the firm.

Many studies have validated the positive effect of innovation on various indicators of firm performance (e.g., Damanpour et. al., 1989; Lööf & Heshmati, 2002). A review of 30 empirical studies by Walker (2004) shows indeed that in about 60% of cases the empirical tests validate the positive relationship between innovation and organizational performance. The majority of the empirical analyses rely on an extended production-function approach, which includes R&D (or alternative measures of innovation effort) as another input to production.

Investigating the relationship between innovation and productivity in four European countries, Griffith et. al (2006) find - consistent with the previous studies - that both product and process innovations have a significant positive effect on firm-level productivity in three out of the four countries. Knell, (2008) revisit the knowledge capital framework within an extension of Erickson & Pakes (1995) and find important effects of R&D investments on productivity. Finally, Parisi, et. al, (2006) apply a modified version of the CDM model and finds that process innovation has a large and significant impact on productivity and that R&D is positively associated with the probability of introducing a new product, while the likelihood of having process innovation is directly linked to firm's investment in fixed capital.

Considering imported capital equipment as part of total factor productivity in growth accounting is related to the issue of what technological change in capital goods means for

productivity. In studying growth in the United States, Cordes et. al (1997) attribute as much as 60 per cent of total factor productivity growth to new technology embodied in capital equipment, while Mankiw et. al (1992) estimates this contribution to be a more modest 20 per cent. In any case, these studies indicate that a substantial part of productivity gains are related directly to new technology embodied in capital equipment.

Micro level evidence of productivity in developing countries that measure the impact of investment in knowledge and innovation is limited. Using data from Tanzanian firms, Goedhuys et. al. (2006) found that the traditional technology variables, R&D and innovation output measures, turned out insignificant in explaining productivity differences. Some indirect technological variables such as foreign ownership, use of ICT and the educational level of the general manager seemed to important determinants of productivity. The lack of empirical evidence on the determinants of TBF performance in Kenya, particularly one that is knowledge-based was the rationale for conducting this study.

2.10 Summary of literature and establishment of research gaps

The literature review presented above indicates the importance of building the innovative capability of TBFs in order to survive global competition. The literature reveals that, the capability to invest in new knowledge and transform that knowledge into innovative outputs determines whether or not the firm performs better than the competitors in today's rapidly changing markets. The evidence from the literature shows that the performance of TBFs depend on the internal and external resources that creates the capability and capacity to engage in technological efforts that creates innovations, that in

turn, are expected to increase the productivity of the firms. The importance of social capital as determinant of innovation and firm productivity has received theoretical and empirical attention in developed countries over several years. The literature reveals that the acquisition of knowledge by firms does not only depend on intra-firm determinant of innovation (e.g. firm size and R&D expenditure), but also on the interactions among different actors, including firms and institutions. Social capital collaboration may be a useful mechanism to offset some of the weaknesses in TBFs' resource endowments in developing countries and bring their innovation capabilities closer to that of their developed counterparts.

Numerous studies in developed and newly developed economies have attempted to explain the drivers of performance of technology-based enterprises by trying to explain differences in innovation activity and pin down the key success factors. Literature has shown that what lies behind superior performance of TBFs in these countries is simply investments that enabled movements along a knowledge production function. The impacts of human and social capital factors on the innovation processes and firm productivity have been studied along with other factors in a knowledge-based framework. Empirical evidence covering innovation activities and technological capability building mechanisms that affect performance of industrial firms in advanced economies has contributed to the design of policies that have boosted their global competitiveness. On the contrary, evidence in this respect that reflects technological and socio-economic constraints in developing countries is lacking. Micro level evidence of productivity in

developing countries that measure the impact of innovation activities in a knowledge based framework is limited.

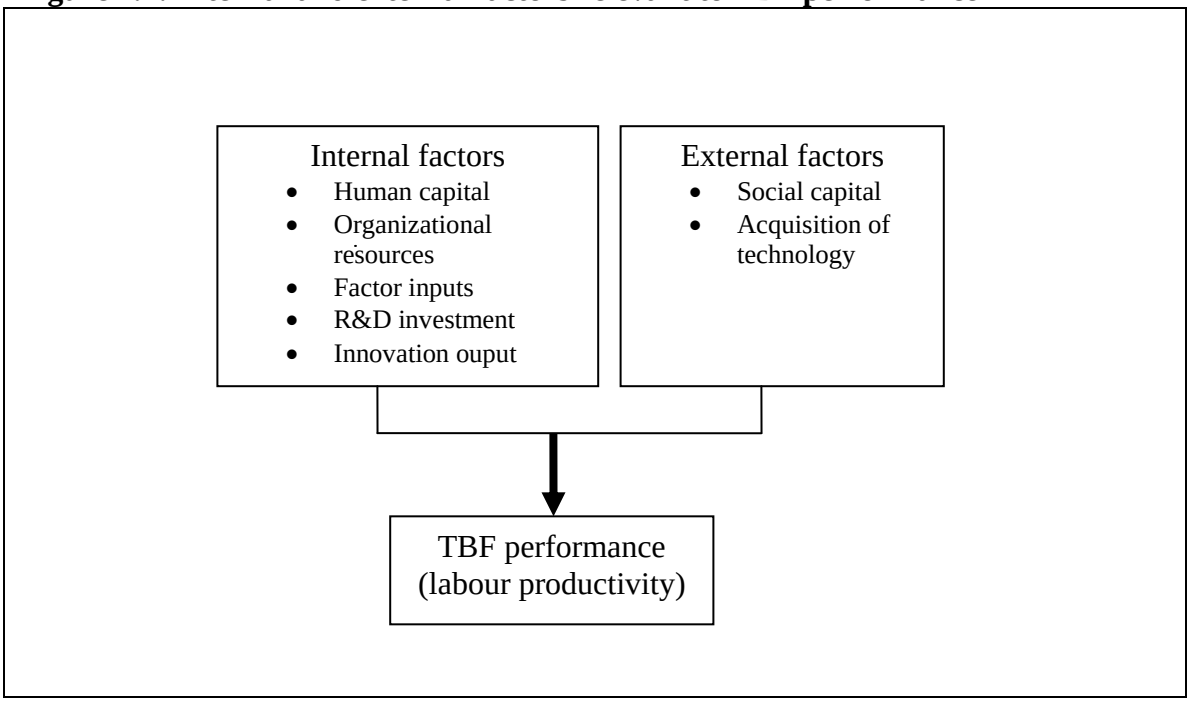
The literature also revealed that despite Kenya enjoying competitive advantages in the areas of prevalence of foreign technology acquisition through licensing and purchase of machinery and equipment, quality of scientific research institutions, and R&D spending, considered very vital in building innovative capability, its innovation capacity falls below the global average. Its innovative capability also ranks low among other sub-Saharan countries compared to best performers in advanced economies and Asian tigers. Since the study that revealed this empirical information used cross country qualitative data, it was important thus to investigate whether the above internal and external business practices and technological efforts reflect innovative capability at firm-level using quantitative methods and determine their role in fueling innovation process and firm performance.

2.11 The Conceptual Model

The extant literature has shown that the performance of TBFs is determined by both internal and external factors. The internal factors relate to organizational resources and capabilities that the firm possesses while the external factors relate to those resources and capabilities the firm may enjoy out of explicit links with other external agents. A simple model is presented in Figure 2.1 and it presents various internal and external factors relevant to firm performance.

However as shown in the reviewed literature, the performance of TBF is a process that depends on the ability of the firm to invest in innovation inputs (R&D and technology acquisition) and transform the inputs into innovation output that in turn is expected to enhance the economic performance of the firms. Therefore the above simple model was modified to capture the complex inter-relationships between internal/external resources and capabilities, innovation input, innovation output and firm performance.

Figure 2.1: Internal and external factors relevant to TBF performance

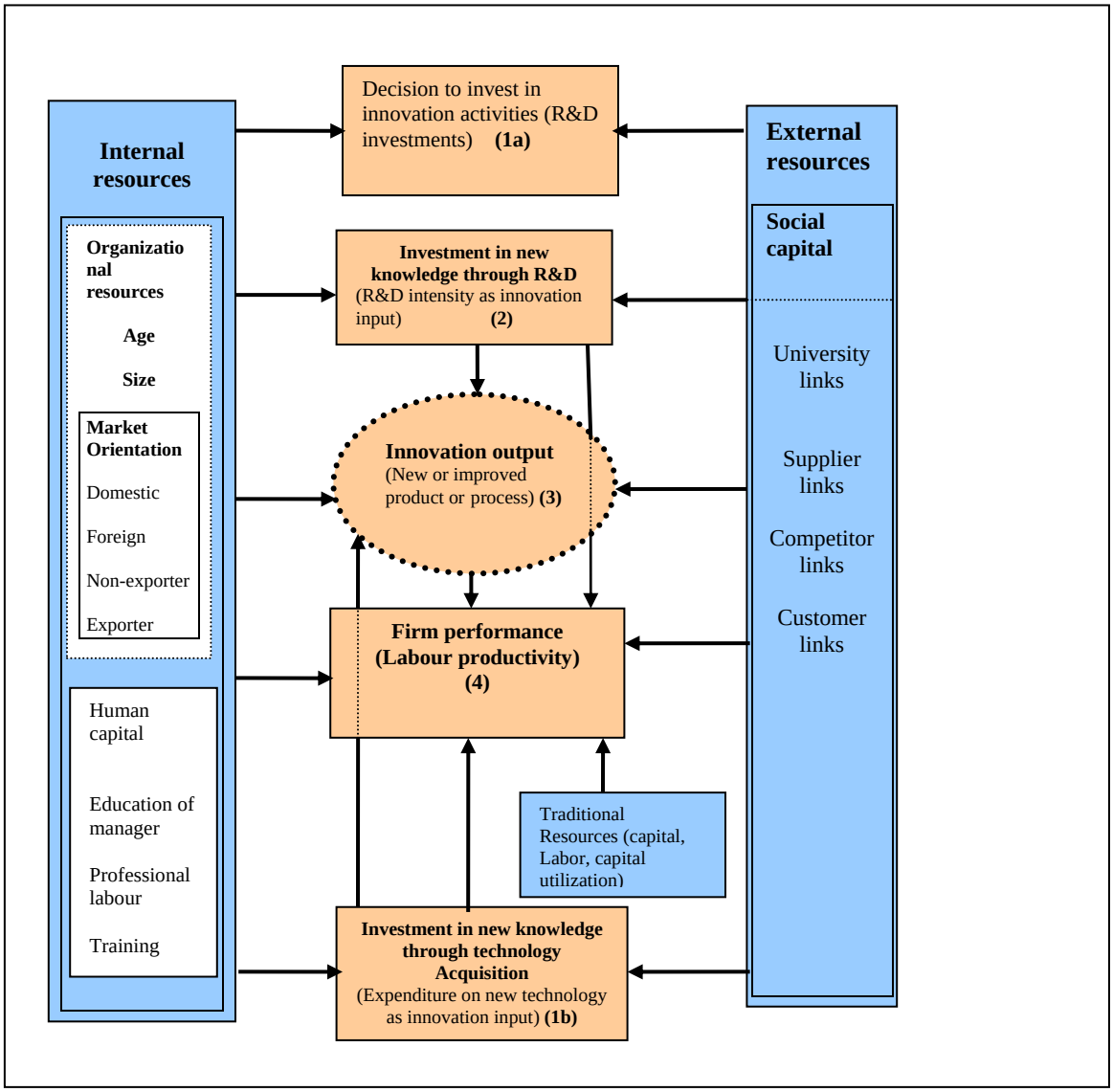


The complete model used in this study is shown in figure 2.2. In generating the complete model, several theories relevant to TBF performance were considered namely:

a) Resource based view of the firm (Barnley, 1991; Hall, 1991; Prahad; 1990). This theory deals with internal organizational resources and capabilities needed for exploitation of knowledge and innovation activities which in turn are expected to affect firm performance; b) Social capital theory (Kline ad Rosenberg, 1986; Dosi et al., 1988)

which deals with external resources and capabilities needed to supplement internal resources; c) Theory of absorptive capacity (Cohen and Liventhal, 1998), which posits that the performance of firms can be enhanced by internal resources, external resources and innovation inputs directly or indirectly through innovation propagation.

Figure 1.2: Conceptual model depicting factors with potential influence on the performance of Kenyan technology-based firms



Square boxes denote measurable quantities. Oval boxes denote unmeasured concepts for which at best there are only course proxies. Source: Model developed by the author in 2009 for this study.

d) Knowledge production approach which explains the transformation of innovation input into innovation output or production of commercially viable knowledge, (Griliches 998);
e) Cobb-Douglas production function approach which links innovation input and output to productivity or more generally economic performance

As shown in the figure 2.2, the first step is to make a decision to undertake innovation activities (R&D activities and other innovation investments) or not. Complimentary to this stage, is also the decision to adopt or acquire technology particularly for firms that do not have adequate technological and institutional capability to create the conditions and environment propitious to engage in R&D activities. Internal and external resources assigned in form of human capital, social capital and organizational resources determine whether or not the firm invests in R&D and technology acquisition. The second stage measures the intensity of R&D and technology acquisition effort. As with the first stage, the amount of organizational, social and human resources assigned at this stage provides a measure of the intensity of R&D activities at the firm level. In the third stage, there is (or should be) an innovation output (process or product innovations) related to the intensity of the innovation efforts. In turn, as innovation is not an end in itself, innovators (i.e. those firms which have launched new or improved products or processes) could be expected to have a better performance than non-innovators (stage 4).

Using the theory of absorptive capacity (Cohen & Liventhal, 1989), the same factors that influence the innovation process are also expected to directly influence firm economic performance. Thus the model has three relationships to be established including the innovation inputs linked to their determinants (question b), the knowledge production

function relating innovation output to innovation input (question c), and the production function relating performance to innovation output (question d).

Firm-level characteristic variables are employed to control for organizational resources and capabilities that may present different technological capabilities arising from firm size, age, ownership and market orientation. Traditional economic factors of production such as physical capital, labour and capital utilization are included as explanatory factors to productivity to determine their relative importance in influencing performance of the firms alongside the technological, firm-level characteristics, human capital and social capital factors. They are also intended to test the proposition that, a higher ratio of value added per employee would not only be driven by an increase in the ratio of physical capital per employee, as some theories of production suggests, but also by inputs and outputs associated with the innovation process.

2.12 Contribution of the model to the body of Knowledge

The model contributes to the body of existing knowledge in the following way: The framework in Figure 2.2 shows the interrelationships between various factors that influence R&D activity, innovation, technology acquisition and firm productivity. It shows the path through which investment in R&D generates knowledge and the forms by which such knowledge transforms into outputs that have productive use (innovations). Various relationships in this figure have been studied extensively in an independent manner, focusing either on the determinants of R&D investments or in patent and innovation production functions, or on impacts of these variables on productivity (Cohen

and Keppler, 2005). In this study, these separated lines of empirical research are combined by simultaneously modeling and estimating R&D, technology acquisition, innovation and productivity, pulling together the largely separated lines of empirical research. This presents a new approach to the study of the interrelationships between investment in knowledge, innovation and productivity particularly in developing countries where investment in knew knowledge through in-house efforts are mostly meant too compensate for insufficient supplies of human capital, advanced machinery and technological knowledge often found in developing countries. .

The other novelty in this approach is that it captures the direct influence of human and social capital factors on innovation input, innovation output and firm performance. Other studies have tried to understand this effect on productivity indirectly through innovation output propagation.

2.13 Chapter Summary

This chapter presented the literature review that is pertinent to understanding what drives the performance of technology-based businesses. The conceptual application of the term "technology-based firm" in the developing countries context was put into perspective. The review laid emphasis on sources of innovative capability and the links between investment in knowledge, innovation and productivity. The conceptual framework focusing on the main determinants of conducting and investing in R&D, technology acquisition, innovation output and firm productivity was presented.

The next chapter presents the methodology that was used in the study. The chapter covers the methods and instruments used in data collection and an overview of methods of data analysis.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter presents the methodology that was used to design and analyze the survey data derived from the study. It includes the research design, identification of target population, sampling and sample size, data collection procedure brief notes on questionnaire construction, and the analytical techniques that were employed in analyzing the data gathered from the respondents.

3.2 Research design

The research design is a plan and structure of investigation so conceived as to obtain answers to research questions (Crewell, 1994). It expresses the structure of the research problem – the framework, the organization, or the configuration of the relationships among variables of the study – and the plan of investigation used to obtain empirical evidence on those relationships (Adams & Schvaneveldt, 1991). In recognition of the fact that no single design exists in isolation, Saunders et al. (2003) postulate that combining different designs in one study enable triangulation and increases the validity of the findings. For this reason two types of research designs were used in this study.

First, descriptive design was used to answer objective (a) which sought to examine the internal and external business practices that characterize the build-up of innovative capability of the firms. The design was applicable to establishing the determinants of performance of TBFs because it describes the technological, human capital, social capital, success factors as while impending factors to innovation that are important in

understanding the profile of business practices for technology-based firms. Second, since descriptive designs do not signify causation relationships (Saunders, 2003) a cause-effect design was used to determine in a more rigorous way the effect of the above factors on firm performance. Econometric techniques were used to relate the causation factors on one hand to the measures of performance relating to investment new knowledge, innovation and productivity. The econometric models established explanatory relationships and in effect the study employed cause-effect research design.

3.3 Target population

The target population of TBFs in Kenya in this study comprised of 772 firms made up of all high and medium-high technology enterprises in Nairobi employing over 10 employees in the section D of the Revised International Standard Industrial Classification Code (ISIC) 2003. In order to arrive at this target population, the classifications developed by Sanjaya Lall (2000) and employed by UNIDO (UNIDO, 2003) combined with those of OECD (2003) was used. Lall distinguishes between primary products and manufactured products and further breaks down the manufactured products into 4 categories – namely resource-based, low-technology, medium-technology and high-technology products (see appendix C). OECD classifies industries based on global technology intensity and breaks the industries into high technology, medium-high technology, medium technology, and low-medium technology and low technology categories (see appendix C).

3.4 Devising the sampling frame

The validity of any statistical inferences drawn from the survey results hinges on having an appropriate sample frame. For this study, the sample frame refers to a list that identifies every firm or any other economic unit within the target population of interest. Such a list was needed so that every individual economic unit of the population can be identified unambiguously. In order to meet these characteristics, the sample frame of this survey was devised in three steps. First, a list containing 2000 officially registered manufacturing companies with 5 or more employees was obtained from the Kenya National Bureau of Statistics (KNBS), which compiled the list during a nationwide census in 2002/03. The list includes all activities in the formal manufacturing sector, which had a total of 250,000 full time employees. It also provides the name, address, sector, International Standard Industrial Classification (ISIC) code, and number of employees for every formal manufacturing firm existing in 2002/03.

The second step was to identify technology-based enterprises from the data base that met the OECD and Sanjay Lall classification criteria discussed in section 3.3. Using these classifications, the Kenyan high and medium-high technology-based enterprises were found to belong to seven industrial sectors namely pharmaceuticals, medical precision and optical instrument, auto and auto parts, electrical and electronics, plastics, chemicals and metal products and machinery. These sectors defined the universe of technology-based firms that were considered in the study.

The third step in the identification of the sample group was to select an economic region with a representative profile. The critical factors used in this selection process were geography, demography and economical activities. The Nairobi province, one of eight provinces of Kenya, was selected. It is the largest province in terms of contributions to the National GDP, has the largest concentration of industrial manufacturing activity, and is representative of the diverse demographic composition that characterizes the country. Using this reduced criteria, a total of 724 Kenyan technology-based firms were identified from CBS data base that had 10 or more employees. CBS is a department of Ministry of Planning and National Development (MP&ND). Since the CBS data base comprised of firms that were in operation up to the year 2002, other sources were used to identify the firms that were established thereafter to the year 2006 before the commencement of this study. The sources that were used included Kenya Association of Manufacturers (KAM) directory of 2005, the National Directory of Industries (NDI) prepared by the Ministry of Trade and Industry between 2003/2004 and the list of firms in the monthly survey of industrial production (MSIP), conducted monthly by Kenya National Bureau of Statistics. These sources identified 48 firms giving a total of 772 firms together with those identified from the KNBS Database of 2002/2003. Thus 772 firms were used as the target universe from which the sample used in this study was dawn.

3.5 Sample size

Stratified random sampling methodology was used in selecting the sample. Stratification was done by the seven industrial sectors identified above and three employment size bands. Taking the number of employees in the KNBS data base and other sources as an

indication of the size of the firm, the following three strata were used: Small size (10-49 employees); medium (50-149); and large (more than 150 employees). These two level of stratification defined 21 clusters.

The minimum sample size was calculated using the following formula according to Saunders et. al (2003).

$$n = p\% \times q\% \times \left[\frac{z}{e\%}\right]^2$$

where n is the minimum sample size required

p% which was 50% and is the proportion of firms who from the pilot study had any form of innovation linkages with other firms and institutions. , This was the variable with the highest variability.

Q% which was 50%, and is the proportion of the firms that had no linkages with any firms and institutions

Z is the value corresponding to the level of 95% confidence required for accuracy of sample size estimation, which was 1.96

e% is the margin of error, that was 5%

Using the formula, the minimum sample size computed was 384 firms from a population of 772 firms. Since the population was less than 10,000 firms, adjusted minimum sample size was calculated using the Saunders et.al (2003) formula indicated below:

$$n' = \frac{n}{1+\left(\frac{n}{N}\right)}$$

where

n' is the adjusted minimum sample size

n is the minimum sample size (as calculated above i.e. 384 firms)

N is the total population (772 firms)

Minimum sample size computed using the two step procedure was 256 firms

However, a problem of most firm-level surveys is that in the majority of the cases the resulting data sets represent only firms that were willing to participate in the survey which systematically might compromise the size and random nature of the sample (World Bank, 2005). Secondly, item non-response, questions with missing responses, is a particularly acute problem in enterprise surveys, especially when dealing with some of the accounting data used to assess firm performance (sales, employment, cost of labor, cost of intermediate inputs and raw materials, net book value of fixed assets, and purchase value of fixed assets). To account for item non-response, the sampling strategy factored in up to a 25% non-response per stratum, so that there was enough valid responses to compute performance indicator with the precision indicated in this sampling methodology. This brought the total number of required interviews to 320 firms which were proportionately distributed according to the size of each stratum by first computing the proportionate sample size by industrial sector and then distributing the resulting sample by size dimension.

Random selection was done to ensure that each firm, according to its size dimension had an equal probability of being selected. The distribution of the sample is shown Table 3.1 below.

Table 3.1: Distribution of the sample

Industrial sector	***Size sub cluster***			
	Small	Medium	Large	Total
Pharmaceuticals	18	12	14	44
Electrical and electronics	17	11	6	34
Metals and machinery	33	22	11	66
Medical & optical instruments	8	5	5	18
Chemicals	26	22	20	68
Plastics	23	19	13	55
Auto and auto parts	11	11	13	35
Total	**136**	**102**	**82**	**320**

3.6 Data collection instruments and procedure

A self-administered structured questionnaire was used for data collection during the field survey.

3.6.1 Questionnaire Construction

In this section, a brief overview of what constitutes the questionnaire used in obtaining the data from the respondents is given. The questionnaire comprised of six (6) sections organized into two (2) distinct parts. These six sections contained qualitative, quantitative or both qualitative/quantitative questions, asking for the manager's opinion on the business environment with regard to innovative activities, resources invested in innovations activities and firm's quantitative estimates that would be used in productivity determination. The respondents were asked to complete the questionnaire by: a) Filling in the "Yes" or "No" boxes; b) Filling in the Corresponding box(es) against a statement or question; c) Filling in the blank field(s) provided; d) Filling in the Likert-Scale Statements.

The questionnaire is briefly detailed in following paragraphs and enlisted in appendix B.

In the questionnaire**,** the Header section identifies the entrepreneur through his demographic information. It includes contact details of senior managers that personalized letters seeking consent for participation were planned to be sent. Section A includes general company information e.g. industrial sector, employment, start-up etc. This section aimed at validating responses against OECD/Sanjay Lall definition of High Technology" or" Medium High-Technology" as well as other control information related to the business environment of the firm. This section was filled out by the enumerator before the interview began. The information required to fill out the header came from the sample frame and the purpose was to verify the accuracy of the sample frame, and update the sample frame information with the information provided from other sources, and to guarantee that the firm is classified correctly with respect to industry and size. It was also meant to understand the market orientation characteristics of the firm by asking questions about ownership and level of exports during the fiscal year preceding the start of the study. A question to determine whether the company was established from knowledge derived from research institutions is asked in this section as well. Section B contains demographic information of the entrepreneur/founder: sex, marital status and level of education. Section C contains qualitative questions and quantitative questions, asking for the manager's opinion on the sources of external technological capability and how these sources are integrated in overall business strategy of the firm. Section D deals with technological innovation and was intended to describe the investment strategy of firms through the innovation activities (innovation inputs in terms of R&D) undertaken and the corresponding innovation outputs. It deals with questions regarding research and

development, patenting and process and product innovations. Questions that were intended to understand innovative activities undertaken by the firms, the important factors for the success and obstacles to innovation were asked in this section as well. Additionally the section attempted to assess the social capital of firms by asking questions on innovation networks with other players in the industry like universities, customers etc. Sections E and F comprised part two of the questionnaire and asked facts and figures specific to the transactions businesses make in order to operate. More specifically, these sections contained questions on production costs, balance sheet information and workforce statistics. Section E comprised of labor statistics: worker skills training, skill availability, employment, education levels of workers; and section F comprised of quantitative questions needed to estimate productivity.

3.6.2 Data collection procedure

The process of implementing the survey involved a number of separate activities. These activities included: a) hiring and training enumerators; b) piloting the survey; c) securing the participation of enterprises; d) making and tracking appointments and tracking refusals to participate and e) administering the questionnaire.

3.6.2.1 Hiring and training of enumerators

The training of research assistants took place from mid to end of April 2007. The aim of the training was to ensure that all enumerators thoroughly understood the instrument to avoid interviewer errors emanating from inconsistent interpretations of questions and interview technique variability. The training process involved classroom type of

teaching, exercises and role-playing to a limited extent. After the classroom work, enumerators were taken through practice interviews to evaluate the effectiveness of the classroom work. This exercise provided feedback that was used to hire the enumerators that were engaged in the piloting and full implementation exercise. Because of the nature of work, the enumerators hired included university staff in the rank of tutorial fellows and MBA students who had basic background in business and accounting principles, the knowledge and experience that was important in helping the companies' staff to pull out the required information from their books and in some cases to help in the construction of information for small companies without formal books of account.

3.6.2.2 Piloting the questionnaire

The purpose of the pilot study was to determine if questions were properly worded and would be understood in the context of the particular participant's business environment. In order to achieve this, a detailed piloting exercise was conducted to test the questionnaire. A trial interview was conducted with four entrepreneurs from each of the seven industrial sectors whom their contacts were available. The interviewees complained about the length of the questionnaire, some technical questions that required explanation and intrusive questions particularly with regard to finances. Consequently the questionnaire was reviewed and most of financial questions removed and replaced with productivity questions. The questionnaire was also appropriately divided into 2 parts that would be administered separately and simultaneously by the enumerators thus collecting a large amount of information without taking too much time. This was in line to World Bank recommendation for carrying out enterprise surveys (World Bank, 2005). Part 2 of

the questionnaire contained quantitative questions about firm productivity and some workforce statistics (see section 3.6.1) which was administered to a company accountant/human resource manager with the consent of the managing director. This strategy was used to take care of concerns about the length of the instrument. Consultations with KAM, KNBS experts and my supervisors helped refine the difficult questions and notes appended to others (see appendix B) for review by participants during the questionnaire completion process. The results of these interviews were not included in the final study.

3.6.2.3 Securing the participation of the enterprise

Before the commencement of the survey the targeted firms were contacted to establish their willingness to participate in the survey. Three hundred and twenty personalized letters were created based on the mail address of the firm, briefly explaining the reasons for the study and asking the would-be participant assistance for cooperation with full assurance for confidentiality (See appendix A). The letters were mailed directly to the attention of the general manager/ managing director of the firm in the second week of May 2007. These letters were followed with courtesy calls after five and ten working days while courtesy reminders were e-mailed to non-responding companies after 15 days of mailing. A number of companies could not be reached either through e-mail or landline calls which could indicate the call numbers or e-mail addresses could have been changed or the companies could have wound up. A total of 182 firms indicated their willingness to participate in the study. However, after carefully considering the number of firms that were unwilling to participate or could not be reached because of any of the

above reasons, and the desire to maintain the sample size, it was decided to replace the those non-willing and non-reachable firms with "new" ones drawn from the population.

3.6.2.4 Administering the questionnaire

The firms were visited in the first week of June, 2007 and the appropriate personnel (managing directors, accountants and human resource managers) were assisted by a trained enumerator to complete the questionnaire. A number of firms requested to be allowed to complete the questionnaire at a later date and an appointment secured when the filled questionnaire could be picked. Many firms particularly the small ones, cited lack of formal book keeping for asking for more time so that they could make the estimates of figures from records that were not readily accessible. Consequently, the part two of the questionnaire was left with the firm to provide time to search for the information and fill out the questionnaire correctly. The data collection exercise ended in the second week of August 2007.

It was also found out that even enterprises that kept formal books were reluctant to reveal their true data on this part of the questionnaire despite, assuring respondents of the confidentiality of their information and the potential value to the enterprise of reform recommendations that would benefit their enterprises. It was also noted that despite having accepted to participate in the survey, several firms, often non-African and foreign firms refused to be interviewed citing lack of time. These firms were however replaced with "new" firms having the same characteristics (by size and sector) as the ones that refused. Due to the high rate of refusal, however, the replacement strategy was only

partially successful and, in the end only 109 firms out of a target of 320 firms (34% of the sample) completed the survey. The total responses were examined based on sector, size and completeness in order to get the valid questionnaires that were analyzed in this study.

3.7 Reliability

Using questionnaires for collecting firm-level data has potential weakness (World Bank 2005). To check the reliability of the measuring instrument, the following procedure was conducted. First, factual (not perceptual) information whenever possible was asked, since subjective measurement that most of prior empirical studies (e.g., Chandler & Hanks, 1994; Jennings & Lumpkin, 1989) used can produce common method bias. Several scholars have criticized subjective measurement of organizational attributes such as measurement using Likert-scales particularly when measuring organizational performance (e.g., Dess & Keats, 1987). Since the subjective measures do not reflect the objective organizational attributes, respondent's characteristics such as personality and social desirability can bias his judgment. To avoid this common method bias, the researcher tried to collect objective measures, whenever possible. Particular emphasis in this respect was given to the collection of productivity data.

Second, scale re-ordering as suggested by Pfeffer & Salancik (1977) was used. The scale re-ordering seeks to reduce the effects of consistency artifacts by arranging the items on a self-report questionnaire so that measures of the dependent variables follow, rather than precede, the independent variables. This method was followed, by placing the firm

performance measures after the measures of firm human capital, social capital and innovation variables.

3.8 Test for validity

Two measures were used to check the accuracy of the reported data. First, triangulation of reported data was done with secondary data to examine the accuracy of the responses using the method developed by Keats & Hitt, (1988). An archival record of sales volume and the number of employees of respondents was collected from KNBS data base and compared this secondary data with reported data. The congruence of data obtained in 72 of the 93 cases (74.4%) supported the validity of the selected variable which also may have reflected favorably on the likely accuracy of other reported data.

Second, possible non-response bias was examined by comparing the characteristics of 25 responding firms with 20 non-respondents that were randomly sampled from non-responding firms. The method followed the procedures recommended by World Bank (2005) for checking the validity of data collected during world wide investment climate assessment surveys for manufacturing firms. The number of total employees of year 2006 of the sampled no- responding firms, in line with the World Bank procedure, was collected from KNBS database and a one-way analysis of variance (ANOVA) conducted showed that size difference (F-value 1.520) between respondents and non-responding firms were not statistically significant. This test indicated the validity of the selected variable, which may have reflected favorably on the likely validity of other reported data.

3.8 Data cleaning

Data cleaning process was taken in order to prepare the data for analysis. Data cleaning was done to eliminate outliers related to size, age, labor productivity and R&D intensity. In the cleaning process the observations with the following were deleted: One responding firm which did not indicate its number of employees in 2006; one value-added per worker values that had suspicious sign; logarithm of employment in 2006 roughly more than four times the sample standard error away from the sample means (2 firms). Missing values for R&D expenditure and other explanatory variables regarding innovators were considered as zero responses. For R&D intensity equation, thus, only firms that had positive expenditures (47 firms) were considered in the econometric methodology.

3.9 Methods of data analysis

Descriptive statistics was used to describe and compare variables meant to answer objective (a) which sought to examine the business practices that reflected innovative capability of the firms. Descriptive analytical tools included frequencies, percentages, mean and standard deviations. The analysis for this objective was also augmented by conducting T-tests on human capital, R&D and social capital by firm size, age and market orientation (trade integration) and by whether the firm was an innovator or not. Question (b), (c), and (d) were analyzed econometrically by relating the separate measures of dependent variable representing the four dimensions under study (i.e. R&D, technology acquisition, innovation output and firm productivity) on one hand and individual idiosyncratic, common and control variables on the other. Question (b) sought to establish the determinants of innovation input measured by investment in R&D and

technology acquisition. This was achieved by modeling their individual determinants separately. Question (c) sought to investigate the determinants of innovation output while question (d) sought to understand the determinants of firm performance. The complete methodology and operationalization of variables and their measurement are discussed in the next section.

Identifying the statistically significant variables in these regressions was an objective way to single out problems or to highlight positive elements that, indeed, matter for the performance of technology-based firms in Kenya. Towards this end, statistical tests were conducted at three levels of significance, 0.05, 0.01 and 0.001 respectively.

3.9.1 Econometric analysis

This section presents the econometric analysis procedure that answers questions (b) (c) and (d) of the study. The three questions are meant to broaden the understanding about the channels linking investment in knowledge, innovation and performance of the firms by separately modeling the determinants of R&D, technology acquisition, innovation and productivity. The individual determinants are related to human capital, social capital, physical resources and firm-level characteristics as shown in conceptual framework in figure 2.2. The main hypothesis underlying the investigation in this section is that firms decide to engage in innovative activities (R&D and technology acquisition) and invest in them in order to develop capability to introduce new products or processes (innovations) that in turn may lead to an increase in economic performance. In accordance with the

received literature, this model allows the decision to invest in knew knowledge (R&D and technology acquisition) and their intensity to be explained by different mechanisms.

3.9.1.1 Model specification and estimation strategy

The basic model consists of a system of five equations: (a) two research and development equations, linking research to its determinants; (b) one technology acquisition equation linking it to its determinants (c) one innovation equation that relates innovation output to innovation inputs (R&D and technology acquisition) and their other determinants; and (d) one equation for productivity with several specifications that relates it to innovative inputs and output as well as other observable variables drawn from the literature.

The R&D and technology acquisition equations help to answer objective (b) i.e. to investigate the factors that influence the firms to invest in innovation inputs. R&D and technology acquisition represent innovation inputs into the innovation process. On its own, the research and development equations aim at disentangling the main factors that accounts for the decision of a firm to engage in R&D activities and those that account for the intensity of those activities. Thus the first R&D specification is a selection equation that accounts for the decision of the firm to engage in R&D activities or not and the second accounts for the intensity of those activities. The rationale for this approach, is that when a firm decides to engage in R&D or not, then it must choose how much to invest in those activities (R&D intensity). The equation for R&D decision (RDD) is modeled as a logit (logistic regression) while R&D intensity (RDRATIO) is modeled as a Tobit. The technological acquisition equations aims at determining the factors that

influence the firms to acquire new knowledge through technologies developed outside the firm. This equation is modeled as a Probit.

The model for innovation output aims to answer question (c) i.e. to determine whether the investment in innovation inputs along with other observable resources of the firms influences the probability of the firms to introduce commercial innovations. As with the R&D decision equation, the innovation output equation is modeled as a logit.

Lastly the productivity model seeks to establish whether the firms invested in innovation inputs through R&D and technology acquisition and launched commercial innovations to the market performed better than those firms that don't have. Thus, the objective of productivity model is to establish the relationships that link investment in new knowledge, innovation and firm productivity.

Each of the above four dimensions of the model has its idiosyncratic as well as common determinants (derived from the literature) related to physical resources, human resources, social capital, and technological resources. The estimation strategy was to have each equation depend on its individual determinants derived from the literature as well common control variables and then investigate their direct and indirect effects as indicated in the conceptual framework in figure 2.2. Thus following the theoretical sequence in the frame, R&D and technology acquisition variables were put as arguments in the innovation output equation, and the innovation output indicator appeared in the labor productivity equation. The econometric technique tested for possible direct effect of

R&D and technology acquisition on labor productivity, which would indicate that R&D or technology acquisition influences productivity through other channels other than innovation output. In particular, the rate of return to R&D (in terms of productivity) was decomposed into a direct effect and an indirect effect that operates through the production of innovation output, that itself feeds onto productivity.

With regard to social capital variables, the estimation strategy on the effects of networking on the innovation input, output and the productivity of firms is as follows: In R&D and technology acquisition equations, the effects of networking in general (see COOP section in 3.10.1) on innovation input among other observable variables were estimated. In the innovation output and productivity equations, additional information on linkages established by the firms was used to investigate how different types of networking partners affect the firms' innovation outcome and firm performance.

3.9.1.2 Normalization of variables

The econometric models for R&D intensity and firm productivity have continuous data as the dependent variables. These variables were normalized by dividing by the labour force and transforming to logarithms to avoid the implicit correlation with the size of the firm. The R&D expenditures entering into the innovation and productivity equations as independent variables were treated the same way for the same reasons. By dividing R&D, and value-added by the labor force, a ratio was produced that was adjusted for firm size, and indicates the shilling of annual R&D expenditures per worker or value added per worker in each firm. Simply stated, larger firms are likely to have more research and

production activities and therefore more R&D expenditures and production output respectively.

Similarly, the variables, whose impact on the dependent variables was expected to be proportional to the percentage differences in their size, were converted to natural logarithms and include age of the firm since establishment, labour force, and capital stock. Like the R&D variable, the logs of these variables were taken so that their impact would vary in proportion to their size, rather than varying as an additive function of level. Those variables not discussed here enter the regressions without further transformations and are entered in the equations as dummy variables. Details about the operationalization of variables measuring each dimension under study are discussed in next section.

3.10 Measurements and operationalization of variables

This section describes the dependent, independent and controls variables entered into the five model specifications. Details of variable construction and measurement are also discussed.

3.10.1 Dependent variables

i) Research and Development. The decision to engage in R&D activities dummy (RDD) and R&D intensity (RDRATIO) are the dependent variables in the research and development equation. The former is a dummy variable that takes on the value of one if the firm has a positive R&D expenditure and zero otherwise. The latter is the ratio of R&D expenditure to labour force. As size variable described below, is measured in terms

of employment, the intensity of R&D is also measured with respect to employment (rather than sales) to avoid a spurious correlation with labor productivity due to measurement errors in sales. Logistic regression was used to estimate the probability of positive R&D expenditure (proxy for the decision of a firm to engage in R&D activities) and a Tobit to estimate R&D intensity. The Tobit model was used in the latter case because 53% of sample firms had no R&D expenditure, and thus, their R&D intensity was zero.

ii) Technology acquisition: Technology acquisition is measured by a dichotomous variable which is a dummy (TECHAQUI), equal to one if the firm reported positive technology acquisition expenditure within the study period (and zero, otherwise).

iii) Innovation output: The dependent variable for innovation equation is measured by a dummy variable (INNOVAT) indicating whether the firm introduced new or improved product or process in the market during the period 2004-2006. Product and process innovations were combined into composite innovation output variable to reduce measurement errors that would have resulted in separating the two due to the few numbers of firms that had introduced either type of innovation.

1v) Firm performance: The measurement of performance of firms is not easy because of multiple objectives involving profitability, employee satisfaction, employment growth, social responsibility, productivity and the ability to adapt to ever changing environment among other objectives (Dollar, et al, 2003). However, the central task in this study was to

identify the factors that matter to the performance of TBFs in Kenya. These factors are related to technology, human capital, social capital and firm-level specific characteristics as indicated in the conceptual model in Figure 3.1. Technically, this objective would be achieved by investigating statistical relationships between performance measures on the one hand and the specific factors indicated above on the other. One of the most informative indicators of firm performance is labor productivity. According to Grupp & Maital (2001), productivity is indeed a key performance benchmark because it relates to the profitability of a firm, its ability to lower costs, and its competitiveness.

Thus, the dependent variable for firm performance is labour productivity, measured by the value added per employee in logarithms. Value added was calculated from the data as the value of total sales minus material purchases and fuel and electricity costs. All values are for the year 2006 and in logarithmic terms.

3.10.2 Independent variables

The list of regressors that were entered in the model includes:

a) Traditional variables. The traditional explanatory variables for labour productivity are the capital intensity, CAPITAL/LABOUR ratio (in logs), and the degree of returns to scale measured by the coefficient of LABOUR (in logs). Labour input was measured by total number of employees in 2006, which was the number of permanent workers employed in 2006. Capital utilization was the ratio of actual output produced /maximum output that could be produced with existing machinery and equipment. The variable capital represents the logarithm of the firm's capital stock by end of the year 2006, and

was constructed by the replacement value of machines and equipment, plus the net book value of land and buildings.

b) Firm-level specific characteristics. Firm-level characteristics are a measure of organizational resources and include the following variables:

i) Firm size: Firm size (SIZE) was measured by logarithm of the number of full time employees of the firms in 2006. Based on the Schumpeterian Hypothesis (Cohen and Levin, 1989), it was expected that the probability to engage R&D activities, R&D intensity, the probability to acquire technology, and firm productivity increase with firm size.

ii) Age: The age of the firm is also a possible measure of its organizational resources. It is a variable commonly used to measure the experience and the learning of the firms in empirical studies of innovation (Kumar & Saqib, 1996). In this study the absolute number of years since the firm was established (AGE) transformed into logarithms was used to captured this effect.

Iii)Foreign: Numerous studies have recognized the effect of ownership structure on innovation, capturing its influence by focusing on foreign ownership (see Becheikh et. al., 2006). Firms that have a positive share of foreign presence may adopt technology from these sources and may enjoy more established linkages abroad that facilitate transfer of knowledge or organizational capabilities that may increase the productivity of the firm.

This effects is captured by a dummy variables FOREIGN which is equal to 1 if the firm had >10% foreign ownership in 2006.

iv) Exporter: Firms that are oriented in the international markets are exposed to foreign markets, which often results in increased technological capability and productivity surge due to a learning-by-exporting effects which are observed for several developing country firms (eg. Van Biesebroeck, 2005, for African firms; Fernandes & Isgut, 2005 for Colombian firms). This effects is captured by a dummy variables EXPORTER which is equal to 1 if the firm had exported >5% sales in 2006.

c) Human capital variables

The ability of firms to generate new knowledge, make use of external technologies and to efficiently convert research results in marketable products depends on their absorptive capacity, especially the educational level of the labour force and the top manager. This is captured by the variables PROFSHA indicating the proportions of professional labour (engineers and scientists), present in the companies and DEGREE, a dummy variable taking on the value of one if the CEO has a university degree and zero otherwise. The variable DEGREE is used as a proxy for the R&D orientation and the capability of innovation of the top managers. Increasing the educational level of the labour force through training, either on the job or through formal training, is generally regarded to be an important aspect of competence building for performing R&D activities and adapting external technology leading to innovative outputs thus increasing firm performance. The

dummy variable TRAINING equals one for firms offering formal training to their employees.

d) Social capital variables

From the literature it was observed that the firms' use of formal and informal external networks enables the firms to acquire resources and capabilities which they may not readily be able to provide. In particular, the use of informal sources of knowledge seems to be associated with the internal capabilities of firms to access and absorb the knowledge produced by other market or research actors more or less immediately. The knowledge derived from formal collaborations seems associated with the use of ideas and developments that result from the access to infrastructures, human capital, and innovative capabilities of partners These resources and capabilities determines the ability of the firms to translate external inputs of knowledge into successful innovations which in turn is expected to result to increased firm productivity. However, the capabilities required to successfully innovate requires different types of partners depending on the type of innovation that firms want to develop. Among the several sources, this study focuses on those linkages that appeared both as sources of knowledge and as partners in R&D and technology acquisition (i.e. collaboration with consultants and in-house sources of information were excluded). The question that asked the firms to indicate whether they had any co-operation arrangements on innovation activities with other enterprises or institutions during the period 2004-2006 and to indicate the type of partner, was used to capture these effects. This question was employed to identify the formal linkages represented by five separate variables: The variable COOP was introduced to capture the effects of innovation linkages in general which was a dummy variable equal to 1 if a firm

had any linkages with other firms and institutions and zero otherwise. This variable was applied only to innovation input variables. Linkages with competitors (COMP), Suppliers (SUPPLIER), Customers (CUSTOM), Universities or other higher education institutes (UNIVERST), all indicated by dummy variables equal to zero if the firm had a formal linkages with any partner and zero otherwise were used to capture the effects of different types of partners on innovation output and productivity.

3.10.3 Control variables

Given that both small and large firms have advantages and disadvantages for innovation (Rothwell & Dodgson, 1994) and that the relevance of specific management practices depends on the firm sector of activity (Ittner & Larcker, 1997), it is common to control for the firm size and sector technological opportunity. Firm size already discussed under independent variables takes care of size effect. However, since all the firms belong to the same technological classification, sector modality is not necessary to take care of technological opportunity (Rothwell & Dodgson, 1994). Nonetheless, based on financial constraints faced by TBFs, in developing countries it is expected that the availability of funds may influence technology acquisition, R&D investment and productivity. The availability of funds (CREDIT) equals to one if a firm has a credit line or a bank overdraft and zero otherwise and is intended to control for access to credit.

e) Other variables

The variables that enter directly or indirectly into the productivity equation are supplemented by two others that could be interpreted as proxies for technology adoption

within the firm and organizational and managing capacity, suitable for the assimilation, improvement and exploitation of existing information. These are the WEBUSE which is a dummy variable equal to 1 if a firm interacts with clients and suppliers through the internet and 0 otherwise, and COMPUT, which an index measuring the proportion of the workers that regularly uses the computer at the work place. These two variables were grouped together under technological variables because they characterize other special aspects of technological activities. The summary of variables entering the model is shown in Table 3.2.

Table 3.2: Construction and definition of the variables

DEPENDENT VARIABLES	
VA/L	**Productivity equation**: Value added per employee, in logarithmic terms Total value added is sales minus material purchases, fuel and electricity costs
RDD	**R&D selection equation**: Dummy variable being 1 for firms that invested in R&D activities. Also enters productivity equation as explanatory variable.
RDRATIO	**R&D intensity**: R&D expenditure per worker in logarithms. Also enters productivity innovation output and technology acquisition equations as an explanatory variable.
INNOVAT	**Innovation output equation**: Dummy variable being 1 for firms that had introduced new product/process or upgraded an existing product line or process in the last three years (2004-06). (also enters productivity equation as explanatory variable)
TECHAQUI	**Technology acquisition equation**: Dummy equal to 1 for firms that reported positive technology acquisition expenditure during the period 2004-2006 and 0 otherwise. Also enters productivity and innovation output equations as an explanatory variable.
EXPLANATORY VARIABLES	
Traditional variables	
LABOUR (SIZE)	Total number of full time employees (in log.)
CAPITAL	Capital stock (in logarithm terms). It includes machinery, equipment, vehicles, land and buildings
CAP_UTILZ	Actual output produced /maximum output that can be produced with existing machinery and equipment (value between 0 and 1)
Firm specific characteristics	
FOREIGN	Dummy variable being 1 if the firm has >10% foreign ownership
EXPORTER	Dummy variable being 1 if the firm has exported >5% sales in 2006
AGE	Logarithm of absolute numbers of the firm establishment
SIZE	Similar to labour
Technological variables	
WEBUSE	Dummy variable being 1 for firms that uses the web to transact with customers/suppliers
COMPUT	Share of workers that uses the computer (value between 0 and 1)

IMPAC	Dummy variable being one if the firm imported new equipment or machinery in 2004-2006
Human capital variables	
DEGREE	Dummy variable being 1 if the general manager of the firm has a graduate or postgraduate degree
PROFSHA	Ratio of professional labour (engineers and scientists) to the total workforce
TRAINING	Dummy variable being 1 for firms that offer formal training linked innovation to their employees
Social capital and finance variables	
COOP	Dummy variable being 1 for firms with linkages with other firms and institutions.
COMP	Dummy variable being 1 for firms linkages with competitors
CUSTOM	Dummy variable being 1 if the firm has linkages with customers
SUPPLIER	Dummy variable being 1 for firms that has linkages with the suppliers
UNIVERT	Dummy variable being 1 for firms that has linkages with the university
CREDIT	Dummy variable being 1 for firms that report not to be credit constrained
Industry variables	
PHARMACEUTICALS	Dummy variable being 1 if the firm belongs in the pharmaceutical industry
CHEMICAL	Dummy variable being 1 if the firm belongs in the chemical industry
AUTO	Dummy variable being 1 if the firm belongs in the auto and auto parts industry
ELECTRICAL	Dummy variable being 1 if the firm belongs in the electrical and electronics industry
PASTICS	Dummy variable being 1 if the firm belongs in the plastics industry
MEDICAL	Dummy variable being 1 if the firm belongs in the medical equipment and precision instruments

The preferred specification at this stage, with assumed "causality" effects derived from the literature can be visualized in Table 3.3. From the model specification and casuality relationship, it is expected that the coefficients of all the independent variables will have positive signs.

Table 3.3: Identification and casualty structure of the model

Determinants	Technology acquisition (TECHAQUI)	R&D Selection equation (RDD)	Innovation input or R&D intensity (RDDRATIO)	Innovation Output (INNOVAT)	Productivity (VA/L)
CAPITAL	X				X
LABOUR					X
CAP_UTILZ					X
SIZE	X	X	X	X	X
EXPOTER	X	X	X	X	X
FOREIGN		X	X	X	X
AGE	X	X	X	X	X
TECHAQUI				X	X
RDD					X
RDRATIO	X			X	X
INNOVAT					X
TRAINING				X	X
CREDIT	X	X	X		X
COOP	X	X	X	X	X
CUSTOM				X	X
SUPPLIER				X	X
UNVERST				X	X
DEGREE	X	X	X	X	X
PROFSHA	X	X	X	X	X

3.11 Pobit procedure for estimating technology acquisition equation

To assess the determinants of technology acquisition, the dependent variable is a simple dichotomous variable (Y), which is a dummy, equal to one if the firm reported positive technology acquisition expenditure within the study period (and zero, otherwise). This situation does not allow for employment of classical regression like OLS without the estimation and interpretation problems (Maddalla, 1983). Therefore a binary quantitative response mode was constructed to handle this leading to the choice of probit procedures that relies on normal distribution assumptions. This binary variable is assumed to be a proxy for a true underlying continuous normal distribution.

The Probit procedure assumes that there is an unobservable underlying response variable y_i*, and that this variable can be determined by the regression relationship:

$y_i^* = \beta x_i + \mu_i$, where x_i is the vector of explanatory (independent) variables, β is the vector of parameters and μ_i is the error term. Thus what is observed is only the dummy variable defined by y=1 if $y_i > 0$, y=0 otherwise, which leads to the probit equation: $Prob(Y=1) = F(\beta X)$, where F is the commutative distribution for μ_i

The independent variables (X) consist of continuous, dummy, categorical and non-categorical variables representing technological, human capital, social capital and firm-level specific characteristics.

3.12 Logit procedure for R&D decision and innovation output

According to what has been previously defined (see Table 3.2), RDD and the INNOVAT are binary variables, which are equal to 1, if the firm invested in R&D or innovated or equal to 0, if the firm did not invest in R&D or did not introduce product/process innovation. The binary data are very common amongst the several types of categorical data and their modeling is part of the general linear regression models (McCullagh & Nelder, 1989). The logistic regression model is the most common one (Agresti, 1996), regarding the assumptions of the independent variable and the way it facilitates substantive interpretation of parameters. Logit regression assumes that the dependent categorical variable reflects an underlying qualitative variable which makes the approach the most appropriate for studies of factors of innovation capability (Kaufmann & Tödtling, 2001; Silva & Leitão, 2007).

Considering the response variable (or dependent) *I*, let *p (I)* be the probability of the firm to invest in R&D activities, *p (I) =Pr [I=1]*. Considering the human capital explanatory variable *H* , as example, let *p(I|H)* be the probability of the firm to innovate according to its degree of human capital, *Pr[I=1¦H=h]*. It is assumed that I follows the binomial distribution, PI~Bin(1,p). In the regression model, the variable of interest, *p(PI)*, henceforth represented by *p*, undergoes the transformation known as logistic function and defined as follows:

$$\log it(p) = \left(\frac{p}{1-p}\right) \tag{1}$$

Where $\frac{p}{1-p}$ represents the odds of success associated with innovation

The logistic regression model is defined as linear in the fixed parameters, β_0 and $\beta_1$has the following functional form,

$$\log it(p) = \beta_0 + \beta_1 H \tag{2}$$

The equation (2) can also be rewritten in terms of probability of success,

$$p = \frac{\exp(\beta_0 + \beta_1 H)}{1 + \exp(\beta_0 + \beta_1 H)} = \frac{1}{1 + \exp[-(\beta_0 + \beta_1 H)]} \tag{3}$$

The extension of this model to multiple explanatory variables, such as the previously defined in section 3.11 is processed through their inclusion in the linear predictor. Since the referred variables comprises of both continuous and nominal categorical data that are recoded to dummy variables (Table 3.2), the linear predictor of the model is specified according the equation (4):

$$Logit\ (p) = \beta_0 + \beta_1 X_1 + \varepsilon_1 \tag{4}$$

where X is a vector of explanatory (independent) variables.

The estimation procedure used in this study is the maximum likelihood procedure.

The logit function establishes the connection between the variable answer and the linear predictor. This is the most commonly used connection function because it easily enables the substantive interpretation of the model parameters (Silva et.al., 2007). Thus, the odds of success concerning innovation have the value $exp(\beta_1)$ for each additional unit in the level of the explanatory variable.

3.13 Tobit procedure for estimating the determinants of R&D intensity

The Tobit procedure is non-parametric alternative to OLS regression often used when variables have extreme skews and thus do not meet parametric assumptions (Tobin, 1958). Tobit considers the situation in which the sample is limited by censoring or truncation thus censoring or truncating the original variable. In the case of analysis of determinants of R&D intensity, 53% of the firms did not have a positive R&D expenditure and thus their R&D expenditure was zero. Thus determining the probability of a firm to increase its R&D spending given its characteristics excludes the firms that had zero R&D expenditure thus altering the sample size (truncation). The Tobit model is the most convenient way of modeling this type of data (Tobin, 1958).

The tobit model is based on the following latent reationship

$y_i^* = \beta x_i + \mu_i$ where x_i is a vector of predictor variables and μ_i is an error term distributed conditionally on x_i. The latent variable y_i^* is only observed when $y_i^* > 0$. In particular the actual dependent variable is

$$Y = \max (0, y_i^*)$$

This procedure fits the analysis of R&D intensity, because the dependent variable is a continuous variable and truncation occurred because values below zero were not observed. Assuming the error terms in the both logistic and Tobit equations are bivariate normal with zero mean and variance equal to unity, like the probit analysis, the equations are estimated by maximum likelihood.

3.13 Analysis of R&D-innovation-performance relationships

This section sought answer question (d) i.e. what is relationship between investment in knowledge, innovation and productivity of technology-based firms in Kenya? This was accomplished by investigating the direct and indirect effects of innovation input, firm specific characteristics, human capital and social capital factors on firm-level productivity. In order to analyze these effects a straight forward Cobb-Douglas production function approach, in line with common practice (see Word Bank, 2005; Goedhuys, et.al., 2006; Ebersberger, &, Lööf, 2005; Söderbom, & Teal, 2006) was used in which a firm's value added is a function of the traditional factors of production, physical capital, labour as well as other observable factors explaining differences in productivity. The proposition this analysis intended to test was that the technological capability to invest in knowledge through R&D and technology acquisition and to transform the knowledge into innovation output positively influences labor productivity of the firms. In other words, a higher ratio of value added per employee would not only be driven by an increase in the ratio of physical capital per employee, as the Cobb-Douglas production suggests, but also by innovation input and output associated with the

innovation process, human resources and resources and capabilities acquired from explicit links with other firms and institutions.

The general estimation equation is a log-linear production function in which the logarithm of value added is decomposed into individual impacts of the total employment, use of capital and other factors outlined above. Value added is used as a measure of performance instead of firm profitability because firms are much more reluctant to report profits than the value of sales and the costs of raw materials. Therefore, rather than rely on profit figures value added was constructed from the information provided on sales and costs of inputs.

Using the straight forward Cobb-Douglas framework and allowing for non-constant returns to scale (Goedhuys, et.al., 2006), the following specification is thus generated

$$Y_{it}=AK^{\alpha}L^{\beta} \qquad (1)$$

where *Y* is the value-added per worker of firm *i* at time *t, L* is the total number of employees (labour), and *K* is the stock of capital. The term A is interpreted as total factor productivity as it captures differences in output across firms that are not accounted for by capital, labour or other material inputs. Thus it is assumed in the above equation, that technological variables (RDD, RDRATIO, INNOVAT, WEB, COMPUT), human capital, social capital and firm-level variables affect only total factor productivity of the firms but not the marginal productivity of labour and capital (Goedhuys, et.al., 2006; World Bank, 2005). Therefore, A=f(X), where X is a vector of productivity enhancing investments which includes technological, social capital and human capital firm-level variables.

Putting all this into consideration and taking logarithms, the following log linear production function was used in econometric analysis

$$\ln Yi = \beta \ln Li + \alpha \ln Ki + \gamma Hi + \delta Zi + \mu Ti + \gamma Fi + \varepsilon \quad (2)$$

where, H, Z, T and F are vectors of human, social capital, technological and firm characteristics respectively and ε is the error term. The coefficients α and β denote marginal productivities of capital and labour respectively. The constants α + β =1 indicates constants returns to scale which was tested empirically. Heterogeneity across firms is captured by the unobserved firm productivity shock, ε. The time subscript (i) was omitted because all the variables refer to the same period (2006).

In order to test the additive effects of innovation, traditional, technological, human capital, social capital and firm specific factors, six different models were ran on the dependent variable. The first model with only traditional variables was used as a benchmark against which to test the effects of firm characteristics on firm performance. The second model has both traditional and firm-level specific characteristics in order to test positive global effects of complementarity in comparison to the first model. The third model adds technological variables to the second model while the fourth model adds human capital variables. The fifth model includes traditional, demographic, technological, human capital and social capital variables. It tests the additive effects of social capital variables on firm performance relative to the fourth model. The last model is a full model that adds the innovation output variable to test the effect of innovation

controlling for the other variables. Since innovation output was hypothesized to depend on other factors, it was important to investigate if its effect on productivity was through a separate model controlling for all the other factors. The estimation procedure was through hierarchical regression, where the relationship between traditional variables on firm's performance, were entered first followed by firm-level characteristics and so on.

The coefficients in the equations can be interpreted as semi-elasticities: i.e., as the percentage change in the value-added corresponding to a unit increase in the variable in question. Specifically, for a continuous variable X measured in percent, the respective coefficient shows the percentage change in the value-added corresponding to a 1% point increase in the value of X. For a dummy, the coefficient is percentage change in the value-added corresponding to a switch in the dummy from 0 to 1.

3.14 Chapter Summary

The chapter covered the methodological procedure used in the study. The data collection methods in the study were described in detail, including the unique problems encountered in the process. Stratified sampling procedure was used to select the sample surveyed. Names of the firms that participated in the study were obtained from National Bureau of Statistics (KNBS) data base and supplemented with those of Kenya Association of Manufacturers (KAM) and National Directory of Industries (NDI). Data cleaning procedures in preparation for analysis and counter measures for dealing with threats to validity were described. Methods of analysis were also outlined in this chapter. The results of the study are presented in the next chapter.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Introduction

The main objective of this study was to investigate the determinants of performance of TBFs in Kenya using the knowledge-based framework. The previous chapter covered the methodology employed to solve the study problem. This chapter contains the findings and discussion of study results that attempted to answer the research questions as derived from the objectives. It is organized on the basis of research objectives. It begins by providing details on the response rate and the firms' characteristics, in terms of socio-demographic and innovation variables. The next section details the profile of responses followed by analysis and results of question one which deals with the business practices and innovative habits that reflect innovative capability of Kenyan technology-based firms.

4.2 Survey response

The response from the survey questionnaire is presented in Table 4.1. From an initial selection of 246 firms, 109 technology-based firms were successfully surveyed. After eliminating 4 firms during the data cleaning process, 105 firms remained for empirical analysis, which is about 34 % of overall sample. This response rate is sufficient to meet generalizability assumptions considering that response rates as low as 3.1 percent have been attained in surveys of technology-based firms conducted elsewhere using mailing techniques (Muroki, 1993).

4.3 General attributes of respondents

The general attributes of the business enterprises was captured using age of the enterprise, type of business activity, legal form and the definition of establishment. Representation of responses by business activity ranges from a low of 3.8% for medical instruments and precision equipment to a high of 21% for both chemicals and metals and machinery. Small firms were represented more in the responding sample (50.4% of the sample) compared to 28.6 and 21% of medium and large firms respectively. This was as expected in the Kenyan context since most of the firms in poor developing countries are normally characterized by small and medium enterprises (SMEs) (see Lundvall & Battese, 2000; Soderbom, 2000, 2001; Mazumdar & Mazaheri, 2003).

Table 4.1: Structure of responses

Firm size (number of employees)	*Number of firms*	*% of Small (10-49)*	*% of Medium (50-149)*	*% of Large (>150) %*	*% of Total*
TBF activity					
Pharmaceuticals	13	7.60	1.90	2.90	12.4
Plastics	19	9.50	5.70	2.90	18.1
Chemicals	22	6.70	6.70	7.60	21.0
Auto and auto parts	14	5.70	4.80	2.90	13.2
Electrical and electronics	11	5.70	2.90	1.90	10.5
Metals and machinery	22	13.3	5.70	1.90	21.0
Medical and precision equipment	4	1.90	1.00	1.00	3.80
Total	**105**	**50.4**	**28.6**	**21.0**	**100**
Market orientation					
Exporter	46	12.4	19.6	12.4	43.8
Non-exporter	59	38.0	9.50	8.60	56.2
Total	**105**	**50.4**	**28.6**	**21.00**	**100**
Ownership					
Foreign	22	3.80	8.60	8.60	21.0
Domestic	83	46.7	20.0	12.3	79.0
Total	**105**	**50.5**	**28.6**	**21.0**	**100**

Source: Author

Considering the market orientation of the firms, data showed sample representation in favour of non-exporters (56.2%) compared to exporters (43.8%). “Exporters” in this study refer to firms that had 5% of sales in export (World Bank, 2005). The proportion of

large firms with export experience was 43.5 % while small and medium firms with export experience were 28.1 and 28.4 respectively. This shows that large firms are likely to be more export oriented than the small and medium firms in Kenya.

With regard to ownership, 21% of the total respondents were foreign-owned firms. A firm was defined as foreign owned when foreign ownership of nominal capital was at least 10 % – this was the benchmark used by the Kenyan national authorities as well as OECD and UNCTAD, (World Bank, 2005). Comparing domestic and foreign firms in terms of size, foreign firms in the sample seemed to be mostly large firms. While 50.9 % of foreign firms were classified as large firms, only 15.7 % of local firms were classified as large firms (see Table 4.2). This is not surprising given that foreign firms have the necessary capacity in terms of resources to set up huge production processes employing heavy capital machinery for large-scale production and at the same time employ huge labour force including many skilled workers.

Table 4.2: Percentage of responding firms by trade integration

	% Small	*% Medium*	*% Large*
Foreign	18.2	30.9	50.9
Domestic	59.0	25.3	15.7
Exporter	28.1	28.4	43.5
Non exporter	67.8	16.9	15.3

Source: Author

Table 4.3 shows the distribution of responses by the age of the business. The results show that roughly more than one third of the responding firms had been in business for less than 20 years while the remaining two-thirds had been in business for over 20 years. The categorical age of the firms also indicate that firms that were established between 31 and

40 years were the most represented. This suggests that Kenyan technology-based firms are well established in the sense that they have been in business for more than twenty years.

The distribution of respondents by organization form is shown in Table 4.4.The results show that majority of the respondents were privately held limited company (85%).

Table 4.3: Distribution of respondents by age of business

Age of business	*Number of respondents*	*Percentage*
10 years or less	15 firms	14.3
11 through 20 years	27 firms	25.7
21 through 30 years	22 firms	21.0
31 through 40 years	36 firms	34.2
Over 40 years	5 firms	4.8
Total	105	100

Source: Author

The other forms of legal status showed marginal representation with publicly listed companies coming second to Limited company with only 5.7% level of presence in the sample. Sole proprietorship had the least representation with only 4 firms responding.

Table 4.4: Distribution of respondents by organization form

Form of organization	*Number of respondents*	*Percentage*
Publicly listed company	6 firms	5.7
Privately held company limited	90 firms	85.7
Partnership	5 firms	4.8
Sole proprietorship	4 firms	3.8
Total	**105**	**100**

Source: Author

On business entry path, the respondents were asked to indicate whether their establishments were a start-up or a spin-off from a company or university where a spin-off means an incorporated commercial entity that derives a significant part of its commercial activities from the application of or use of technology and know-how developed by or during a research program within a firm or university. The responses are indicated in Table 4.5.

Table 4.5: Percentage of responses by start-up definition

Definition of establishment	*Number of respondents*	*Percentage*
Start-up	93 firms	88.6
Corporate spin-off	10 firms	9.5
University spin-off	2 firms	1.9
Total	**105**	**100**

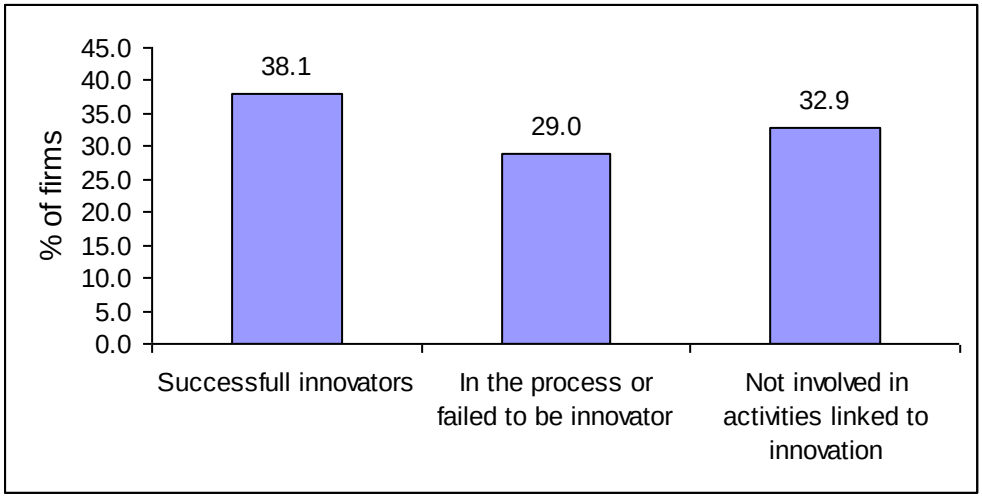
Source: Author

The results indicate that majority of the firms (88.6%) are fully independent company (start-up) and were not established as a result of use of technology or research developed in company or university. Only two firms reported that their firms were established from technology or know-how developed in the university. This is interesting considering that technology-based firms in developed countries spun from significant application of scientific and technological knowledge developed in the universities (Wong, 2000).

4.4 Occurrence of Innovation

Figure 4.1 shows the proportion of firms that introduced innovation in the period 2004-2006.

Figure 4.1: Percentage of respondents reporting innovation by type



The definition of innovation was based on the Bogota manual (OECD, 2003) for innovation surveys in Caribbean and Latin America and included new or significantly improved products and processes that the firm implemented during the 2004-2006. Therefore a firm in this study is considered an innovator if it reported having introduced new or improved products or processes (or both) during that period. The figure shows that a small proportion of firms introduced innovations in the three year period. As seen in the figure only 38.1% of firms had implemented a new or improved product or process. Quite a proportion of the firms (almost one in three firms) consist of firms who tried to innovate, but have either failed or have not yet competed projects leading to a new or significantly improved product or process. Almost the same number (32.9%) did not try to innovate and, therefore, were not engaged in activities liked to innovation.

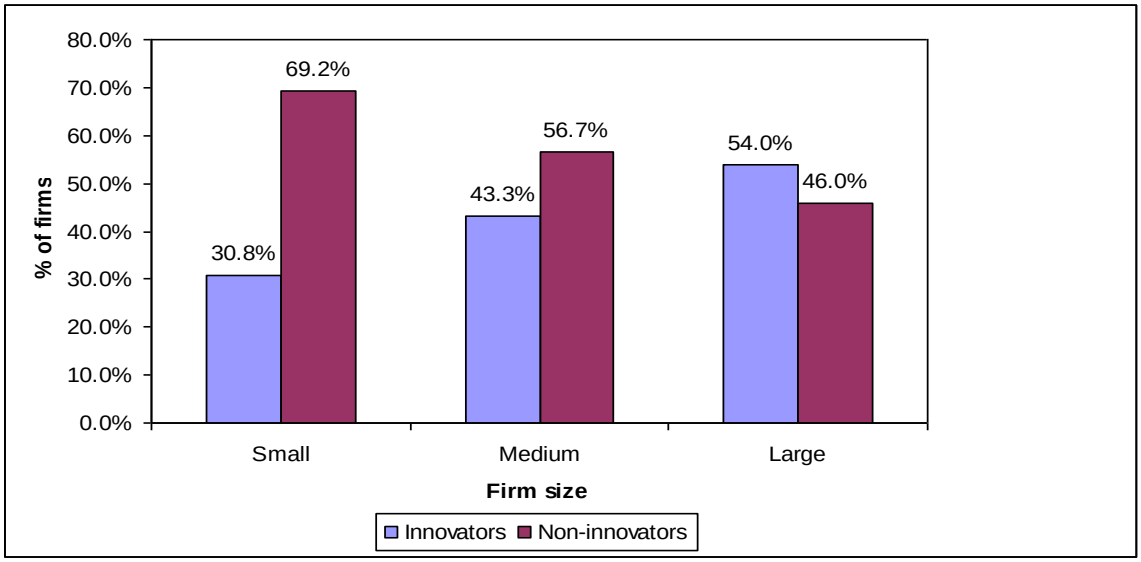
4.4.1 Occurrence of innovation by firm size

Figure 4.2 shows the percentage of innovators versus non-innovators disaggregated by firm size to demonstrate size differences. Non-innovators included unsuccessful innovators and firms that were not involved in activities linked to innovation. The two

groups were combined and called “non- innovators” because both of them had failed to introduce innovation in the period 2004-2006.

The results show that large enterprises are more innovative (54%) compared to 30.8% and 43.3% for small and medium firms respectively. The independent T-test results presented in appendix D indicates the differences between large and small firms to be statistically significant at 0.05 level. These results are consistent with the Schumpeterian hypothesis that posits that large firms are more innovative than smaller firms when stressing the process of creative accumulation. However, these findings are inconsistent with others studies reported in a US survey (Edward & Theodore, 1984) and the Netherlands (Link & Barry, 1987). The study in US found out that small technology-based firms accounted for about 55% of all innovations identified in the survey while the Netherlands study estimated small and medium firms to produce about 2.22 as many innovations as large firms.

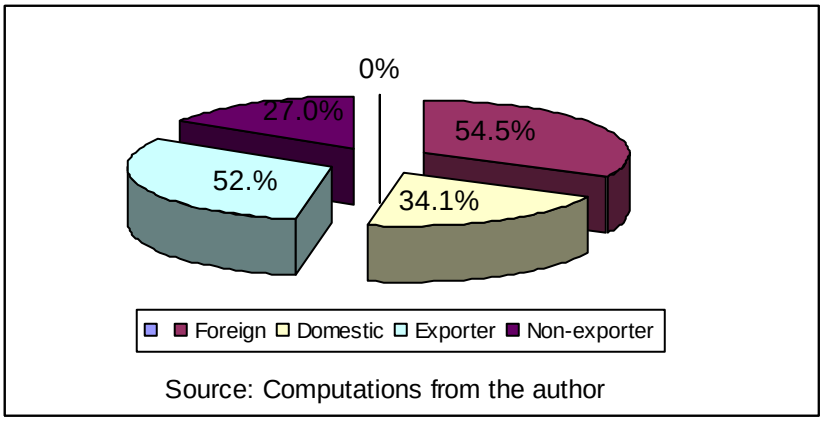
Figure 4.2: Percentage of innovators by firm size



4.4.2 Occurrence of innovation by trade integration

Figure 4.3 shows the percentage of firms that introduced product/process innovation in the period 2004-2006 disaggregated by trade integration. More than one-half of responding foreign (52%) are innovators while only about one in every three (34%) of domestic firms have introduced innovations within the same period. The percentage of exporting firms that are innovators is almost twice more than that of their non-exporting counterparts (54.5% versus 27%). T-test results shown in appendix D indicate significant differences between foreign and domestic firms at $p<.05$ while between exporters and non-exporters the differences are significant at $p<.001$.

Figure 4.3: Percentage of innovators by trade integration



Source: Computations from the author

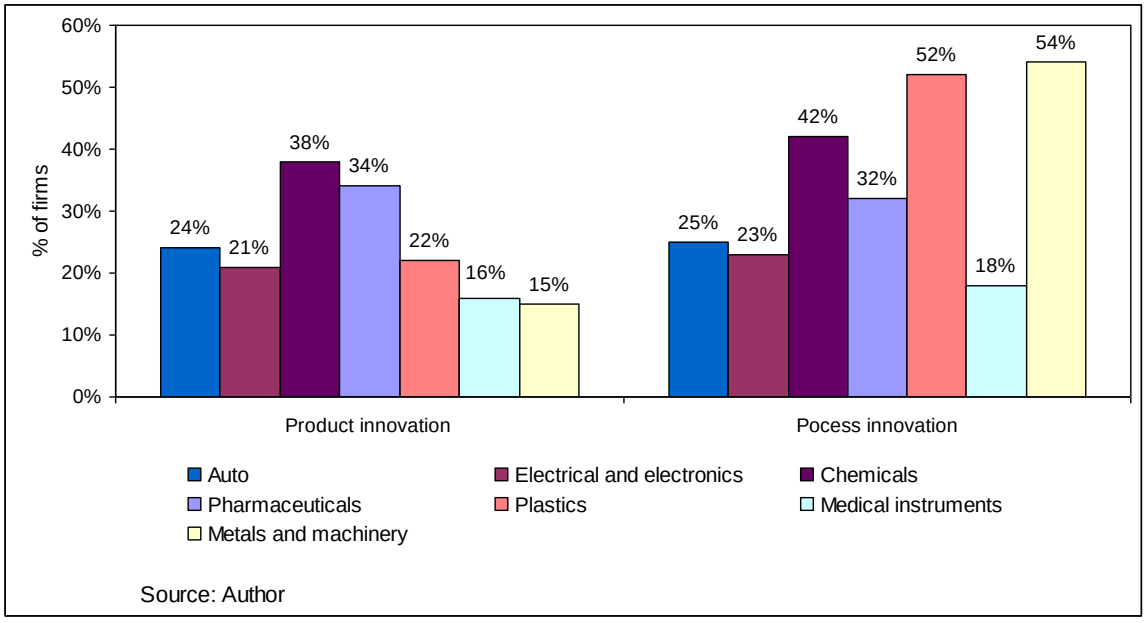
The results suggest that firms that are integrated more in the international markets have better innovative capability compared to their local counterparts.

4.4.3 Occurrence of innovation by industry and type of innovation

Figure 4.4 shows the incidence of innovation disaggregated by industry and type of innovation to demonstrate sectoral differences by type of innovation. Comparing the innovative performance by type of innovation, the results show that all the industries

introduced more process innovations than product innovations. Since technological innovation deals with products and processes (Hadjimanolis, 2003), it is evidenced that the firms' performance is rather poor in product innovation. The absence of patents by many firms during the period under review further attests to this fact. Only four companies in the sample had applied for a patent within the study period, one in the chemical industrial sector and three in the pharmaceutical sector. Interestingly, these are the same sectors that had relatively high incidence of product innovations compared to the other industries. The two industries had more than 38% and 34% of the innovators reporting to have introduced product innovation during the three year period.

Figure 4.4: Percentage of firms reporting the two types of innovation by industry



The absence of patents during the period under study indicates that the innovations were incremental as opposed to radical which underscores the poor performance of TBFs in Kenya in generating knew knowledge and converting it into products that would be able to capture specialized niche within the world's leading markets. Within the developing

country context, many authors agree that minor or incremental changes can be the most frequent type of innovation activity, together with innovative applications of existing products or processes (see e.g. Polcuch et.al., 2005).

Comparing the innovative capability of the firms by process innovation indicates the performance of the firms in favour of plastics and metals. This is explained by the fact that both sectors belong to the class of technology-based process industries that often put considerable technological effort in improving equipment and optimizing complex processes in order to be competitive (Lall, 2000) which is ultimately an act of process innovation. Surprisingly, medical precision and optical instruments appear to be less innovative on both product and process innovation (less than 20 % of firms are product or process innovators). This is surprising considering the high technological component required to do business in this industry.

4.5 Business practices that reflect innovative capability

The analysis in this section tries to answer the question "What are the business practices that reflect innovative capability of TBFs in Kenya? The analysis outlines the findings on the firm's innovative habits and practices as reflected in the kind of innovative activities it engaged in during the 2004-2006 reference period. Sources of innovation capability are related to human capital, social capital, and technological efforts captured by resources devoted to R&D activities. The extent to which firm-level differences in innovative capability occur may vary by industry, by size of the firm or market orientation, by industry, and capability building strategies pursed by individual firms. This section thus

attempted to understand the firm-level innovation capability differences by comparing the technological and innovative efforts of the firms bearing in mind the influence of the above firm-level characteristics. More specifically the activities are presented for firms of different size, ownership, exporting experience and by whether the firm had innovated or not during the period 2004-2006.

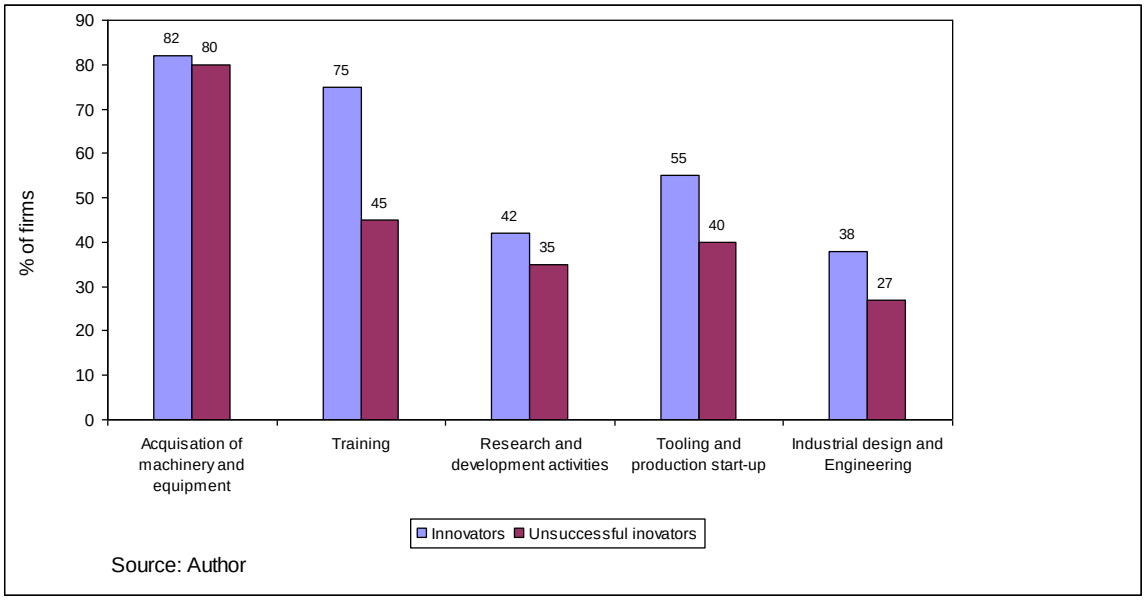
4.5.1 Activities linked to innovation

Figure 4.5 show that the firms primarily acquired innovation capability by acquiring new machinery and equipment (82% and 80% for innovators and unsuccessful innovators respectively). The striking feature of this figure is that, although there is a minor difference between successful and unsuccessful innovators engaged in the acquisition of machinery and equipment, unsuccessful innovators are much less likely than successful innovators to get involved in other complementary activities to innovate, such as: training, R&D, tooling up and industrial engineering. Less than 50% of unsuccessful innovators indicated they participated in these complimentary activities (45%, 35%, 40% and 27% for training, R&D, tooling up and industrial engineering respectively). Innovative firms also seem to rely more on tooling up and industrial design than R&D activities (55% compared to 42% respectively. Literature suggests that a firm performing R&D enhances its technological absorptive capacity. According to Lall (2000), most technology in Africa is imported from more industrialized countries, one would not expect to find much innovation-oriented R&D going on in Kenya but one would expect, however, to observe technical efforts going on to modify imported equipment, to

differentiate local product designs, to re-engineer or copy foreign machinery and goods, and so on.

Besides the principal task to support the future development of new products or new processes, performing R&D also permits a firm to use more efficiently embodied technology acquired externally in form of acquisition of machinery, equipment or other technology (Cohen and Liventhal 1989). As a learning process that generates and builds absorptive capacity within firms, it allows the adoption, imitation and adaptation of others' discoveries. As stated by Cassiman & Veugelers (2000): "The performance of a firm's innovation strategy that relies on successfully integrating externally acquired technology, depends on the ability of the firm (by its internal research capacity) to appropriate the benefits from this innovation".

Figure 4.5: Types of activities linked to innovation



Therefore, doing R&D or buying embodied technology should also be accompanied by a qualified labour force to be fully efficient. Several authors pinpoint the importance of

complementarities between employees' skills, firm's competencies and innovation (Leiponen, 2000). As noted in the introduction, R&D activities (inputs to innovation) are not sufficient to assure that a firm will be innovative, however, it is rather a complex interaction of factors or activities (where R&D activities remain important) that lead a firm to be innovative. Therefore, being involved in only one or a few activities would restrain firms' technological absorptive capacity and, as a result decreases the likelihood to innovate. This is consistent with findings from Figure 4.5 where unsuccessful innovators are less likely than successful innovators to be engaged in several activities linked to innovation.

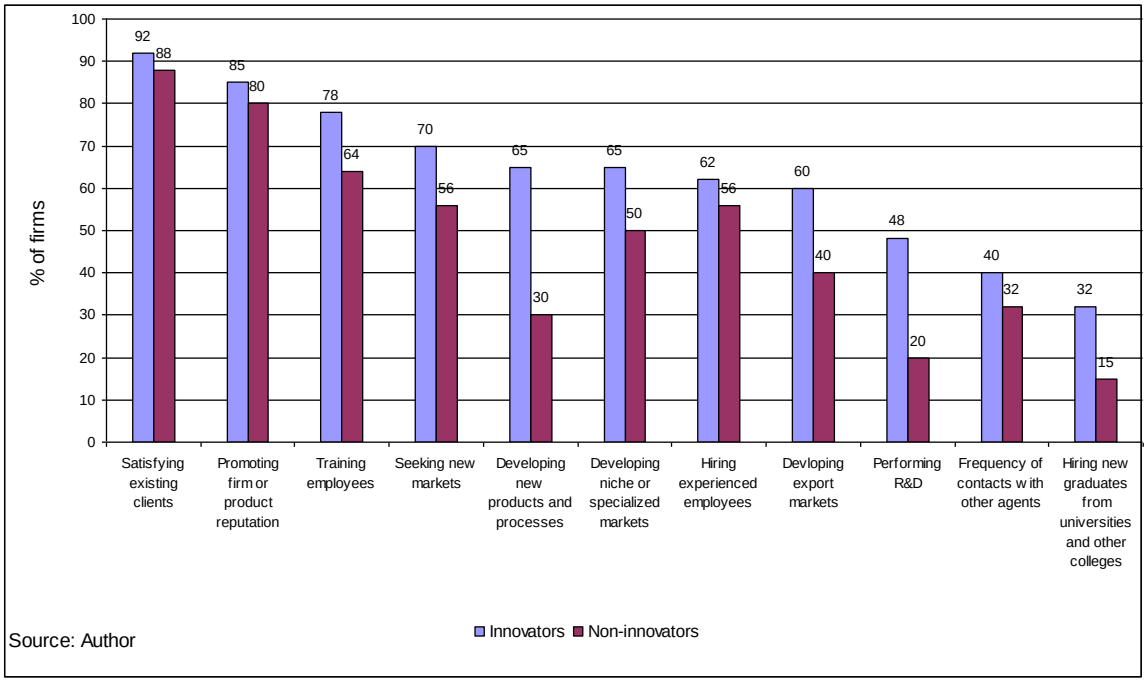
4.5.2 Success factors for innovation

What do the Kenya technology-based firms consider as important factors to undertake innovations? An enterprise may innovate due to internal success factors (such as the having experienced human capital, capability to conduct R&D etc) or external factors (such as desire to satisfy the clients, capability to engage in collaboration arrangements etc). This study identified a mix of internal and external factors considered as important for successful innovation by both innovators and non innovators. The results are displayed in Figure 4.6.

The figure shows that both innovators and non-innovators share the same view on the importance of consolidating markets for innovation success. Both of these groups considered satisfying existing clients and promoting firm or product (good or service) reputation as the most important success factors. Experienced human capital is also seen as important to firm's success. While training employees and hiring experienced

employees are important factors for firms' success, hiring new graduates from universities or technical schools and colleges are considered only of minor importance. This finding is quite interesting. It shows that firms put more emphasis on the informal learning system (training and experience) than in the formal schooling system. Firms prefer to hire experienced workers and/or giving a specific training (based on the firm's specific needs) to their employees instead of using the more formal and general education system.

Figure 4.6: Percentage of innovators who indicated the following factors are most important or important for firm success



Innovators place a higher priority on developing new products and processes, and on performing R&D than non-innovators. The likelihood of reporting that developing innovations or performing R&D (as firm's success factors), is much higher for innovative firms than for other firms. These results may not be surprising as firms which are not involved in innovation activities are unlikely to report that performing R&D or

innovating are of much importance to them. However, comparing only successful and unsuccessful innovators shows that successful innovators are also more likely to report that these activities (see Figure 4.5) are important to their success than unsuccessful innovators.

As mentioned earlier, hiring new graduates from universities or colleges are considered only slightly important (as measured by their ranking). Nevertheless, innovative firms are more likely than non innovative firms to mention them as an important success factor.

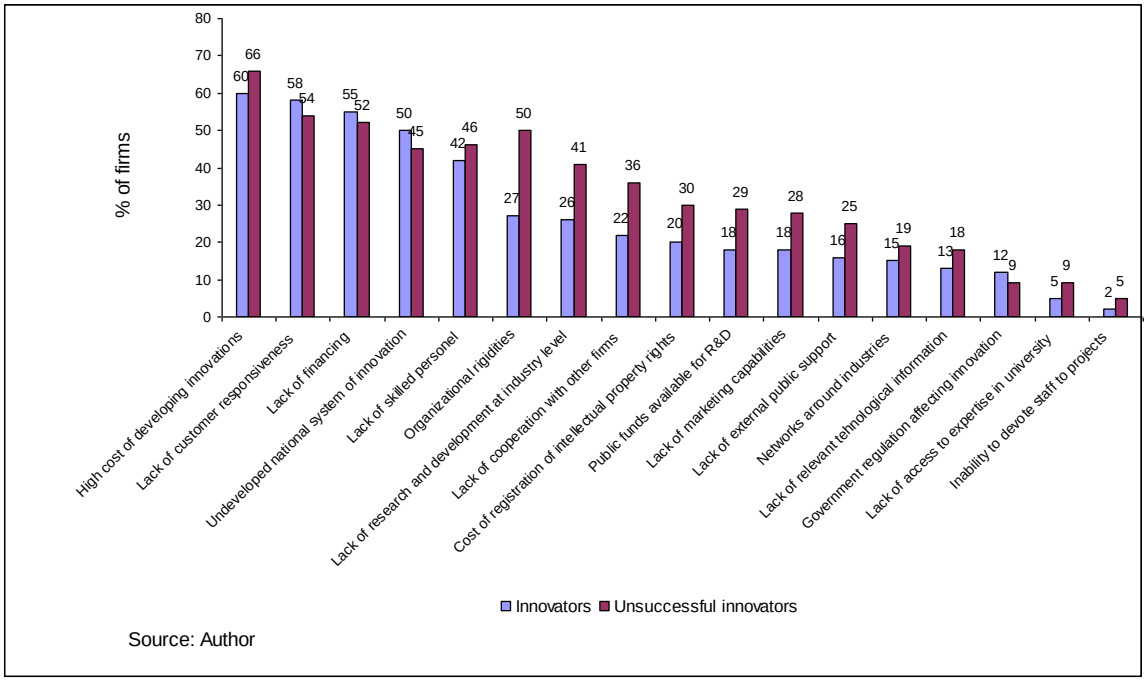
Finally, even though involvement in collaboration with other firms ranked quite low (14^{th}) for all firms surveyed, the likelihood of seeing collaboration as an important success factor is much higher (twice as likely) for successful innovative firms.

4.5.3 Obstacles to innovation

This section seeks to find out the major impediments to innovation by the Kenyan-technology-based firms. As noted in the previous section, the firm's propensity to innovate is little and skewed against small firms. Figure 4.7 presents the full list of potential constraints to innovate, along with the percentage of firm managers that said the item presented a "major" or "severe" constraint to innovate. The figure displays results for both innovators and non-innovators. Based on the responses of firm owners and managers, this study identifies four critical constraints to innovate: lack of customer responsiveness, high costs of developing new or significantly improved products or processes, lack of financing for conducting R&D activities and undeveloped national

system of innovation. Only these four impediments out of the seventeen are recognized by more than half of the respondents, whether they are innovators or non-innovators. Lack of qualified personnel and unavailability of public funds for R&D were also rated significantly (more than 40% of firms) as an important impediment to innovate by both innovators and non-innovators.

Figure 4.7: Percentage of firms who reported major obstacle to innovation by type



Source: Author

Organizational rigidities was ranked as a severe constraint by 50% of non-innovators against 27% of innovators indicating lack of creativity by non-innovating entrepreneurs/managers as expected according to the Schumpeterian theory of innovation.

Except for lack of cooperation with other firms in the industry, the cost of intellectual property protection, and the other factors discussed above, all the other impediments were

judged as important by less than 30% of Kenyan technology-based firms. For instance, the lack of access to relevant technology, government regulations affecting innovation or access to expertise in university and government laboratories that could assist in developing or introducing innovations (reported as important by only 13%, 12% and 5% respectively by innovators) are not seen as major impediments to innovate.

Polcuch et. al (2005) described the characteristics of innovation in developing countries, highlighting the specific characteristics of the economy and society that influence the innovation process. These authors believed that local markets in developing countries tend to be small – in some cases due to less developed technological infrastructure - reducing the scope of the firm's actions and relevance of actual innovations. It is therefore not surprising that one of the key obstacles to innovation identified in this study is weak national system of innovation and customer demand. Interestingly, lack of technological information as discussed above is considered as only a slightly significant obstacle to innovation by both innovators and non-innovators. An implication of this is that the problems of the firm do not largely arise from paucity of technological information but in the internal capabilities of the firm to effectively deploy this information. These are consistent with the findings of previous studies in the developing country context (Bala-Subrahmanya, 2005; Desai & Taneja, 1990; Ramasastry & Krishnaswamy, 1979)

4.5.4. Human capital and innovation capability

According to Romjin & Albaladejo (2002), human resource is a vital element for industrial competitiveness. With the pace of technical change, the spread of information

and communication technologies and intensifying global competitiveness, the need for skill development has become even more commanding. As TBFs are expected to generate new knowledge and to use more sophisticated technologies, the need for more advanced, specialized skills on the part of both workforce and managers emerges as important. The gap between the workforce and certified specialists like engineers and scientists may determine the innovative capability of individual firms. The education profile of a firm's workforce can contribute to its innovative capabilities, particularly the presence of university-trained engineers. Table 4.6 shows the firm's full-time employees breakdown for all the firms. The aim of this analysis was to determine the education profile of workforce that is important to the attainment of innovation capability.

Proportions of technicians and technical professionals (scientists/engineers) are seen to be very low (about 6% and 15% of total workforce respectively) as against the proportions of administrative and non- technical professionals and factory workers (about 18% and 47% respectively). In fact, the majority of the firm's total workforce (about 71%) has either secondary school or vocational qualifications. The proportion of staff with university qualifications (about 11%) is considered low in technological terms because it includes the administrative staffs that make little or no technological contributions (Romjin & Albaladejo (2002).

Although the majority of firms (56.7) had CEOs with a postgraduate degree considered to be very relevant to their current job functions in a technology-based businesses, the majority of the firm's workforce has pointed out above does not have university

education. This index suggests that the skills level of the firm's workforce, which is a key determinant of innovation capability, is rather low.

Table 4.6: Breakdown of educational background and professional specialties

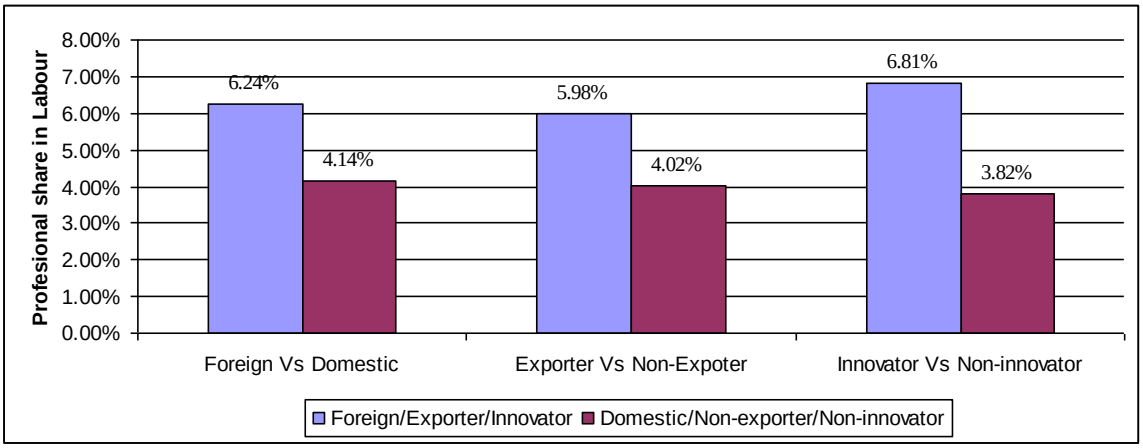
Professional specialties of the workforce	***Percentage of total staff***
Management	18.34
Engineers/scientists	5.75
Technicians	15.05
Others	47.24
Total	**100**
Highest educational achievement of employees	***Percentage of total staff***
University education	11.12
Vocational/Technical	26.5
Secondary education	45.23
Primary education	20.34
Total	**100**
Highest education level of top manager	***Percentage of firms***
Postgraduate degree	56.7
University degree	15.4
Vocational training	5.8
Secondary education	22.1
Total	**100**

Source: Author

4.5.4.1 Human capital endowment by innovation and trade integration

In this section, the analysis is directed at exploring the differences in technical human capital endowment of domestic-oriented vs. the export-driven companies; foreign vs. domestic; and innovators vs. non-innovators. The technical human capital endowment is represented by the share of certified professionals (engineers/ scientists) in the labour force and is a measure of "potential stock" for innovation considered very important in the build-up of innovative capability of technology-based businesses (Katz, 1988). The results are indicated in Figure 4.8.

Figure 4.8: Technical human capital endowment by market integration and innovation



The results indicate that foreign firms, exporters and innovators generally enjoyed higher firm-level capabilities than domestic, non-exporting and non-innovating firms as measured by the professional share in labour index. Foreign firms had 6.24% of its worker force comprising of certified engineers and scientists compared to 4.1% of domestic firms. Innovators had a human capital index of 0.0681 versus 0.0382 for non-innovators while exporters had 0.0598 compared to 0.0402 for non-exporting counterparts.

The results of T-Test analysis presented in Table 4.7 showed the difference to be statistically significant for foreign, exporting and innovating firms. This was expected since firms that are integrated more in the international markets usually undertake more human resource development activities than those that are locally integrated, generally meant to drive production in a foreign country and to compete in international export markets (Rasiah, 2004). The presence of university-trained engineers/scientists

contributes to innovation capabilities of firms as it is critical in conducting R&D activities, and to adapt and operate new machines and equipment (Romijn, 1997).

Table 4.7: Professional share T-test difference of means by innovation and market integration

	Mean	*Mean difference*	*P-value*	*T-statistic*
Exporter	0.0598			
Non-exporter	0.0402	0.0149**	0.044	2.142
Foreign	0.0662			
Domestic	0.0414	0.0403*	0.092	1.512
Innovators	0.0681			
Non-innovators	0.0382	0.0299***	0.001	3.342

Source: Author. Note: *Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

4.5.5 Research and development effort

The analysis in this section seeks to understand the intensity of investment in R&D activities and whether the effort is successful in enhancing innovative capability of the firms. The results are shown in Table 4.8 and 4.9 for those firms that reported positive R&D expenditures in the period 2004-2006.

Table 4.8: R&D expenditure per worker by innovation and firm size

	Mean (Ksh)	*S.D*	*Observations*
All s surveyed firms	41, 888	108, 076	105
Innovation (all firms)			
Innovators	72, 442	141, 808	51
Non- innovators	10, 274	13, 696	54
Innovators (by firm size)			
Small	143, 813	190, 408	22
Medium	10, 927	14, 982	16
Large	23, 615	42, 022	12

Source: Author

Table 4.8 provides some basic descriptive statistics for the sample broken down for mean and standard deviation values of R&D expenditure per worker disaggregated by firm size and whether the firm was an innovator or not. The results show that there is a great deal of variation in R&D expenditure per worker between innovating and non- innovating firms. The mean expenditure for innovators tend to be seven times (Ksh. 72, 442) more than that of non-innovators versus (Ksh. 10, 274) and this can be interpreted to mean that more firms undertake R&D activities among innovators than non-innovators which is in line with the expectation from the literature. Nevertheless, not all firms reveal the same levels of accumulation of capabilities, to invest in research activities as the standard deviations in the Table reveals. For non-innovators, the firms reveal almost similar capabilities (S.D of 13, 696 which is close to the mean of 10, 274) while for innovators the investment capability deviates significantly. The standard deviation of 141, 808 compared to the mean of 72, 442 indicates that some innovative firms are at a disadvantage in attaining resource capability to invest in in-house R&D activities. The variation in capability accumulation appears to be explained significantly by small innovative firms as the standard deviation of 190,408 compared to the mean of 143, 813 associated by this group of innovators reveals.

The figures in the table also reveal that small innovative firms spend higher on R&D per worker (average of 143,813 Ksh/worker) than medium and large firms which is Ksh 10,927 and Ksh 23,615 respectively. This is an interesting result that goes against scholarly view that the interpretation of large fractions of innovations attributable to small firms need to be reconciled with the fact that large firms spend much larger sums of

research and development. For the firms the absolute number of R&D performers and the sums involved appears to be on the side of small firms.

Table 4.9 indicates the R&D spending as a percentage of sales. The results indicate that more than two-thirds (68.1%) of the firms devoted less than 0.5% of the firm's annual turnover to R&D spending while only one-fifth (21.3%) devoted between 0.6% to 2.5% of the turnover to R&D.

Table 4.9: Ratio of R&D to sales

R&D as a percentage of sales	*Number of respondents*	*Percentage of respondents*
0.5% or less	32 firms	68.10
0.6% - 1.5%	6 firms	12.80
1.6– 2.5%	4 firms	8.50
More than 2.5%	5 firms	10.60
Total responding	**47**	**100**

Source: Author

In most developed and newly developed economies, private sector R&D is quite extensive. In Japan, for instance, about 50% of all firms in the economy devote between 1.5 and 2.4% of their turnover to R&D; in Australia the figures are as high as 5% of turnover in about 30% of private firms (Liao & Greenfield, 1997).

Evidences from South Korea indicate that 76% of all R&D were carried out by private firms in 2005, an increase of over 48% from 1960 (DST, 2005). While at this point it may not be possible to establish whether or not there is a connection between R&D and

productivity, this empirical evidence suggests that intensive and formalized industrial R&D could be key drivers of growth in these advanced economies.

With close reference to the skills of the firm's workforce, as analyzed above, and R&D activities ranked close to last amongst the innovative activities undertaken by successful innovators, it is not surprising that very few patents were reported by the firm during the reference period.

4.5.6 Social capital and innovative capability

This section looks at whether there are firm-level differences in establishing network relationships by firm size, trade integration and by whether the firm is an innovator or not. The analysis is meant to understand the characteristics that predispose the firms to seek external relationships in order to supplement internal resources and capabilities for innovation. The analysis is based on the composite variable which indicates whether or not a firm had any form of innovation linkages with other firms and/or institutions (Universities, customers, suppliers and competitors). Test of difference between means by ownership, innovation, market orientation and firm size are explored using T-test statistics. The tests are presented in Table 4.10. The results reveal that non-exporters, were much less likely to engage in any form of partnership compared to the exporting ones : less than one out of two (45.6%) small firms had engaged innovation linkages , compared to almost three out of four (76.1%) for exporting firms. Similar differences were observed between foreign and domestic firms; large and small; and innovators versus non-innovators. Interestingly over 90% of foreign firms had some sort of innovation collaboration compared to only around 50% of domestic firms.

Tale 4.10: T-Test difference of means for collaborating firms by size and export status

	Mean	*Mean difference*	*P-value*	*T-statistic*
Exporter	0.761			
Non-exporter	0.456	0.305***	0.002	3.257
Foreign	0.909			
Domestic	0.506	0.403***	0.001	3.586
Small	0.490			
Large	0.727	0.237	0.062*	1.893
Innovators	0.611			
Non-innovators	0.363	0.311	0.051*	3.124

Source: Author

Note: *Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

The percentage of foreign, large and innovating firms that had linkages with other firms and/or institutions were significantly different from those of domestic, small and non-innovating firms respectively at least at 10% level. These results suggest that firms that are integrated in the international markets rely more on external relationships with other firms and institutions to supplement their resources and capabilities for innovation than the local counterparts. Similarly, the results suggest that large firms and innovators may rely more heavily on external knowledge networks as an input to innovation than do small and non-innovating firms.

4.6 Econometric results

This section of the study presents the results and discussion of questions (b) (c) and (d) of the study. The three questions are meant to broaden the understanding about the channels linking investment in knowledge, innovation and performance of TBFs in Kenya by separately modeling the determinants of R&D, technology acquisition, innovation and productivity. The presentation of results starts with descriptive statistics and results of

collinearity diagnostics conducted on the independent variables used in the econometric analysis.

4.6.1 Summary of descriptive statistics

The descriptive statistics together with their correlation matrix is shown in Table 4.11. The data shows that only 32 % of the firms used technology acquisition (TECHAQU) as input to innovation compared to 43% that used in-house R&D activities (RDD) as innovation input during the study period. Only 46% of the firms conducted some innovation related training within the period. On technology adoption variables, the results indicate that more than four-filth (82%) of the firms had at least some workers in their firms using computer while 69% of the firms used the web to communicate with suppliers and clients. The level of capital utilization (CAP_UTILZ) was 61% while 71% of the firms had CEOs with at least a university degree. Turning to innovation networks the analysis finds very little evidence of collaboration with research institutes and/or universities. Only 3 % of the firms had innovation linkages with universities and research institutes, which means there were no proximity advantages gained by the firms from the universities and research institutes.

Table 4.11: Descriptive statistics and correlation matrix

Source: Author. Note: p < .05 if | r | >.13

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1. LOGVADD	3.18	0.51	1.00																				
2. CAPTUTIL	0.60	0.19	0.28	1.00																			
3. LABOUR	1.75	0.44	0.02	0.03	1.00																		
4. CAP_UTILZ	4.89	0.55	0.55	0.20	0.06	1.00																	
5. AGE	1.29	0.37	0.15	0.12	0.16	0.03	1.00																
6. EXPORTER	0.44	0.50	0.22	0.28	0.31	0.29	0.03	1.00															
7. FOREIGN	0.21	0.41	0.20	0.11	0.33	0.06	0.24	0.21	1.00														
8. RDD	0.59	0.49	0.22	0.06	0.17	0.17	0.11	0.16	0.10	1.00													
9. RDRATIO	4.32	0.54	0.12	0.11	0.14	0.18	0.00	0.24	0.15	0.01	1.00												
10.COMPUT	0.52	0.50	0.22	0.14	0.22	0.10	0.13	0.11	0.16	0.06	0.04	1.00											
11. WEBUSE	0.49	0.47	0.32	0.23	0.43	0.19	0.04	0.37	0.19	0.13	0.03	0.31	1.00										
12. TECHAQU	0.51	0.43	0.31	0.10	0.41	0.15	0.17	0.26	0.16	0.05	0.10	0.48	0.54	1.00									
13. DEGREE	0.53	0.41	0.12	0.08	0.10	0.09	0.12	0.16	0.25	0.03	0.02	0.11	0.03	0.02	1.00								
14. PROFSHA	0.05	0.07	0.18	0.04	0.18	0.07	0.01	0.02	0.06	0.22	0.38	0.19	0.14	0.22	0.06	1.00							
15. TARINING	0.46	0.50	0.14	0.05	0.23	0.02	0.17	0.11	0.05	0.01	0.17	0.15	0.14	0.08	0.01	0.14	1.00						
16. INNOVAT	0.40	0.49	0..20	0.24	0.15	0.18	0.06	0.22	0.16	0.07	0.05	0.16	0.25	0.34	0.17	0.14	0.19	1.00					
17. CREDIT	0.57	0.50	0.13	0.01	0.19	0.13	0.10	0.07	0.02	0..21	0.15	0.14	0.09	0.30	0.07	0.05	0.17	0.35	1.00				
18. COOP	0.63	0.40	0.22	0.11	0.05	0.26	0.07	0.25	0.10	0.05	0.04	0.19	0.17	0.06	0.10	0.09	0.14	0.09	0.03	1.00			
19. UNVERST	0.24	0.42	0.06	0.14	0.08	0.09	0.02	0.12	0.06	0.08	0.04	0.12	0.01	0.19	0.01	0.14	0.08	0.24	0.12	0.03	1.00		
20. CUSTOM	0.43	0.50	0.38	0.02	0.08	0.17	0.06	0.28	0.31	0.05	0.01	0.18	0.17	0.20	0.15	0.16	0.01	0.35	0.20	0.23	0.12	1.00	
21.SUPPLIER	0.58	0.49	0.12	0.04	0.07	0.06	0.04	0.10	0.21	0.09	0.04	0.01	0.07	0.07	0.08	0.06	0.07	0.11	0.02	0.00	0.25	0.13	1.00

On the contrary, the firms collaborated with competitors, suppliers, and customers to solve their problems with the highest percentage of firms collaborating with customers (48%) followed by suppliers (42%). This pattern of collaboration where a gap exists between the research knowledge system and industry is characteristic of the developing country context where the National Innovation Systems are highly fragmented (Polcuch, 2005; Egbetokun et. al, 2007).

The coefficients of correlation in the table gives a first insight into the relationship between social capital, human capital, firm characteristics, innovation inputs, innovation output and labor productivity of the firms. Student tests were run to assess the statistical significance of the coefficients. Most coefficients are positive and significant at the 5% probability level especially for labour productivity. This suggests that a firm that has better human resources, and engages in networks linked to innovation develop the technological capability to acquire new knowledge through R&D and technology acquisition, and to transform that knowledge into innovative outputs that increases the performance of the firm as measured by value-added. It is also noted that most indicators of the four dimensions under study are not highly correlated among each other. They seem therefore to form a coherent set of factors on which the innovation process and firm productivity relies rather than independent substitutable resources and capabilities. The correlation matrix also indicates that there are no bivariate multicollinearity problems where correlations greater >.90 (Belsley et. al., 1980) was used as defining criterion. Test for multivariariate multicollinearity which builds on regressing each independent on all others indicate the absence of autocorrelation where tolerance of <.20 and variance

inflation factor (VIF) >=4 (Belsley et. al., 1980) were used as the cut-off criterion (see appendix E).

4.7 Estimation results for technology acquisition equation

The results of the probit procedure on the probability of acquiring new technology are indicated in Table 4.12.

Table 4.12: Probit equation explaining technology acquisition equation

Independent variables	***Probit coefficient***	***p-value***
AGE	-0.377**	0.024
SIZE	0.383*	0.067
EXPOTER	1.36	0.163
CAITAL STOCK	1.35	0.163
DEGREE	1.42**	0.012
PROFSHA	0.124**	0.025
TRAINING	1.26	0.152
RDRATIO	0.130**	0.013
CREDIT	1.130	0.158
COOP	1.15**	0.034
-2log likelihood 48.698	48.698	
Nagelkerke R^2	57.836	

Source: Author

*Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

The results from the estimation are presented in terms of probability indices (z-scores) instead of marginal effects because the model of SPSS (version 11.5) software used does not support the latter. Consequently the discussion of the results concentrates on the sign of the coefficient and not its magnitude. The results show that the probability of acquiring new technologies appears to be positively affected by several specific effects: human capital as proxied by the education of the top manager (DEGREE) and the level of certified engineers and scientists (PROFSHA), social capital as represented by networks

between the firm and other firms and institutions (COOP), and firm specific characteristics represented by the age (AGE) of the firm. On the human capital side, the results indicate that the quality of workforce and management is correlated with technology acquisition. The variable on training of workforce is positive but not statistically significant. The level of the firm's investment in R&D also contributes significantly to the probability of a firm to acquire new technology. A firm that exports also gives a positive probit index though not statistically significant when other variables are in the model. The positive probit index for capital stock suggests that TBFs in Kenya have higher probability of improving their technological capability through acquiring new technology.

Not surprisingly access to credit increases the probability that a firm acquires a new technology. Results also suggest that younger firms have a higher probability of adopting new technology which is consistence with the fact that less adaptation efforts are needed according to late comers' advantages theory by Macedo (2004). The effect of employment size also increases the probability of acquiring a new technology reinforcing the interpretation that it indicates the incidence of more physical and financial resources associated with larger firms (Penrose, 1952).

All together, these results seem to be consistent with the hypothesis that equipment acquisition is the main channel of technology adoption in developing countries (Correa et. al, 2005). There are also indications that R&D and labor training are required as complementary investments, consistent with the fact that technology acquisition normally needs adaptive efforts from recipient firms (Rogers, 1995). Moreover, the adoption

behaviour of the firms is closely linked to its networking environment. It is evident from the results that cooperation with other firms and institutions (COOP) has significant effect on technology acquisition. This finding suggest that networking creates effective exposure for external learning that greatly contributes the firm's ability to evaluate and better implement the newer technologies and processes (Parhi, 2005).

The analyses confirm most of the theoretical predictions advanced in the literature about technology acquisition as a source of innovation input. It emerges from the analyses that firm specific characteristics of the firm remain as crucial variables for the acquisition of new technologies due to their sheer impact on the economic viability of the large investment in them. Larger firm size coupled with a richer stock of its human capital base is found to give a potential edge to firms to become more innovative through technology-acquisition. Moreover, a greater investment in R&D is also seen to greatly enhance the acquisition of new technology. The results strongly supports that greater internal resources enable the firms to better innovate in the economy.

The log-likelihood statistics, comprising 48.69, also corroborates the global significance of the model, when compared with the null model. The Nagelkerke coefficient of determination indicates that the model explains 57.8 % of the total variation.

4.8 Estimation results for the research and development equations

The results of the empirical analysis on the factors that determine the probability of engaging in R&D and those that account for the intensity of those activities are presented

in Table 4.13. Model 1 shows the results of the logit analysis on the probability of conducting R&D (RDD). Model 2 shows the results of the Tobit analyses on R&D intensity (RDRATIO).

Table 4.13: Logit and Tobit results explaining R&D decision and intensity of R&D investment

	R&D dummy (RDD)			*R&D intensity (RDRATIO)*	
Indicator variable	Model 1 (Logit)			Model 2 (Tobit)	
	coefficient	S.E	Odds ratio	Coefficient	S.E
Constant	-5.31***	1.89	0.005	-0.285**	-0.052
AGE	0.641	0.717	2.414	0.275	0.391
SIZE	2.060**	0.717	7.849	0.106	0.492
DEGREE	0.484	0.609	1.622	0.127*	0.005
PROFSHA	1.708**	0.578	5.517	0.034	0.041
CREDIT	1.740**	0.592	5.693	0.134**	0.035
COOP	0.597*	1.437	1.816	0.1280*	0.076
EXPORTER	1.685***	0.408	5.392	0.146**	0.046
FOREIGN	-0.359	0.613	0.699	-0.180	0.401
-2 log likelihood	88.175			102.6	
Nagelkerke R^2	39.8				

Source: Author

*Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

With regard to the probability of conducting R&D (RDD), SIZE, COOP, PROFSHA and CREDIT have positive and significant coefficients, as expected. The other variables have no significant effects though all coefficients are positive. The advantage ratios regarding R&D activities are 7.849, 1.816, 5.570 and 5.693 for SIZE, COOP, PROFSHA and CREDIT respectively. Thus, for TBFs in Kenya, availability of qualified personnel and access to finance and collaborative networks are found to be the most important determinants of a firm's decision to invest in innovation activities. The findings show that controlling for industry, larger firms with access to credit lines, firms that have collaborative arrangements and firms that have trained specialists outside of management are more likely to develop R&D activities. The positive relationship with size is well documented in the empirical literature (Crepon, et. al., 1998; Benavente, 2002). Larger

firms are more prone to take risks and more able to appropriate the results of their innovations.

With regard to R&D intensity (model 2), CREDIT, EXPORTER and DEGREE have positive and significant coefficients, as expected. However, other variables - AGE, SIZE, FOREIGN and PROFSHA, do not have significant effects. Thus, access to finance, educational background of the CEO and being an exporter, have positive effects on R&D intensity; while firm size, qualified human resources, foreign ownership and technological opportunity presented by cooperation with other agents firms and institutions have no significant impacts.

With regard to social capital effects, data shows that linkages with other firms and institutions (COOP), as in the case of R&D decision, also enhance the probability of the firms to invest in R&D. In the RDRATIO model, the coefficient of COOP is positive as expected and significant (at $P<0.1$), pointing out a complementary relationship between networking in the innovation process and the level of the firms' innovation input in terms of R&D. These findings are in line with work done in other countries (Sakakibara, 1997; Veugelers, 1997). Inter-organizational arrangements in R&D expand technological capabilities with stimulating impacts on the firms' research intensity.

The estimation results suggest that the determinants of conducting R&D and those of R&D intensity are partially different. In particular, educational background of the CEO has significant effects on the R&D intensity of the firms, but not on whether they conduct R&D, while firm size has effects on the decision to conduct R&D activities and not how

much to invest on them. The findings that the educational background of the CEO and the availability of funds affect the R&D activities of the firms are not surprising because it is expected that the activities of technology-based firms to depend more heavily on the ability of the CEO and financial constraints than do those low technology-based firms. Similarly, the estimations support the hypothesis that exports have a positive and significant impact on both the decision o engage in innovation activities and how much to invest in them.

The estimation results are partially consistent with those of the previous studies. With regard to the effects of educational background, availability of qualified personnel and access to finance, the results obtained are similar to those of major previous studies (Griliches, (1988); Griffith, et.al., (2006); (Johansson & Lööf, 2008). However, the results with regard to firm size indicates that as Kenyan technology-based firms get larger, they invest less in R&D which is inconsistent with the Schumpeterian hypothesis about innovation being an activity largely undertaken by bigger and largely more market dominant firms. The descriptive statistics on R&D intensity disaggregated by firm size (Table 4.7) showed the ratios in favour of smaller firms.

In both specifications of the model, the estimation shows that foreign ownership is not a relevant explanatory variable. In other words, foreign owned firms are not more prone to be engaged in innovation activities or to invest more in them compared to domestic firms which indicate that firms with links to foreign sources of technical knowledge do not necessarily engage in internal innovative activities.

4.9 Estimation results for innovation output equation

The logistic regression estimations of determinants of innovation output are shown in Table 4.14. It is noticed that seven items out of thirteen estimations of the regression parameters are statistically significant at least up to 5%, in which the p-values was used as test statistics.

Table 4.14: Logit regression explaining innovation output equation

	B	*S.E.*	*Exp(B)*
Constant	24.075	24.451	759.89
Firm characteristics			
SIZE	1.291*	0.266	3.283
AGE	-2.03	-2.05	0.131
EXPORTER	1.180**	0.277	3.282
FOREGN	0.733**	0.261	2.081
Innovation input Variables			
RDRATIO	2.11	1.52	4.520
TECHAQU	0.610**	0.202	1.840
Human capital variables			
DEGREE	0.669***	0.128	1.952
PROFSHA	0.493*	0.112	1.638
TRAINING	0.438	0.241	1.545
Social capita variables			
SUPLLER	0.365	0.273	1.441
COMP	0.552	0.311	1.737
CUSTOM	0.578**	0.266	1.782
UNIVERSIT	-4.409	7.022	0.103
Model Summary			
Correct predict (%)	79.10		
Log Likelihood	39.867		
Nagelkerke R^2	69.40		

Source: Author
Note: *Significant at 10% level; ** significant at 5% level; *** significant at 1% level.

Starting with variables representing the firm specific characteristics, the estimations show that firm size has a positive and significant influence on innovation output of the firms. Therefore, the bigger the size of the firm, the greater the propensity of the firm to

innovate. The punctual estimations of the parameters associated with size enterprises 1.291. These results follow the empirical research done by other scholars (see Bönte, 2003); Romijn, 1999). As the marginal effects of the dummy variables are analyzed, the probability of the firm to innovate its product/process has an increasing positive relationship with the size of the firm. The advantages ratio shows that as firm size increases the advantage ratio increases to 3.283. With respect to market orientation variables, the data shows that foreign ownership and exporting intensity of a firm has a positive effect on innovation output of the firms as expected. The positive effect of exporting intensity on innovation confirm the theory in the literature that learning by exporting influences innovation.

Relative to the inputs of innovation, the results show that the technological effort measured in R&D expenditure/worker and technology acquisition have positive effect on innovation of the firms though only technology acquisition dummy is statistically significant at 5% level. The variable coefficients have positive values as expected and their advantages ratios are 1.84 and 11.17 respectively. However since the estimation parameter of R&D investment is not significant, it indicates that there is no clear relationship between the firm's innovative performance and the extent of research effort undertaken, in the form of total R&D resources invested per employee. The significance of technology acquisition variable indicates that the probability of introducing innovations by TBFs in Kenya is enhanced significantly more by technology acquisition expenditures than R&D investments.

Interestingly, there is only one notable link between the reporting of performance advantages associated with social capital variables on the one hand, and their innovation capability on the other. Only linkages with customers appear to have positive and significant effect on the probability of the firms to innovate while contacts with universities and suppliers and competitors are not significant. The findings that only local contacts with customers have significant effect on the probability of the firms to innovate is consistent with the idea, often voiced in recent literature, about the importance of intensive ongoing contact with customers for development of products that suit new market needs (Love, 2001), but also suggest that most of innovations reported by firms are incremental as opposed to radical (Kaufmann & Tödtling's, 2001). While the cumulative effects of such innovations on competitiveness should not be underestimated, it is highly unlikely that specialized niches in the world's leading markets could be captured without major innovations (Cowan & van de paal, 2000). The literature indicates that the type of partners a firm engages in networking determines the type of innovation occurring: customers for incremental innovation; suppliers for major innovation; and universities for radical innovation (Love, 2001). This finding together with low investment in R&D reported under section 4.9, explains why the firms reported very few patents during the study period and could as well explain the poor high-tech export performance by Kenyan technology-based firms. It could also lead to conclude that, Kenya's institutional science base has not been valuable source to enhancing innovative capability of the firms in the sample. While technology-based firms drives its competitive advantages from the application of knowledge generated from research institutions, this appears not be the case for Kenya. This is further re-reinforced by the

finding in Table 4.5 that indicates that only 2 companies in the sample reported to having been established from knowledge generated from universities and research institutes.

Finally, the variables measuring human capital of the firm increase the probability of the firms to innovate. Both the parameters associated with the share of professionals in the workforce and education of managers are positive and significant as expected (0.669 and 0.493 respectively with the former being significant at 99 % confidence level). The estimation supports the hypothesis that labour skills are important in converting innovation inputs to innovation outputs.

Overall, these results corroborate the assumption of complementarities of activities linked to innovation. Being involved in several activities to innovate drastically increases the likelihood of introducing innovations. These results are not surprising as several studies stress the increasing complexity of technology. As noted by Rycroft & Kash (1999), the range of technologies required for innovation has also expanded as innovation has moved closer to the scientific frontier and technologies have become more complex. Nowadays, a firm must combine all kinds of activities performing R&D; training employees; buying equipment and machinery which embody technological knowledge, participating in export markets; as well as, collaborating with external entities to improve their firm's capabilities to innovate.

The predictive capacity of the model is 79.1%, which results from the comparison between the values of the variable answer predicted by the model and the observed values. The log-likelihood statistics, comprising 29.867, also corroborates the global

significance of the model, when compared with the null model. The Nagelkerke coefficient of determination indicates that the model explains 69.4 % of the total variation

4.10 Econometric results for innovation input-output-performance equation

This section presents the results of objective (d) sought to investigate the relationship between investment in knowledge (through R&D and technology acquisition), innovation and productivity of the firms. The results starts by reporting a series of global tests conducted by comparing successive models tested by using incremental F-test, as shown in the bottom of Table 4.15. The first global test indicates that Model II, which includes firm specific characteristics, as well as traditional firm productivity variables, explains value-added significantly better than Model I (F Change= 6.504 at p=.001) with predictive power increasing to 39.7%. The combined effect of age and market orientation variables together increases the explanatory power by 18.1%. Similarly the effect of technological variables is positive as can be seen in the results in model III. The model indicates that controlling for traditional inputs to productivity and firm specific characteristics, technological input variables can increase the explanatory power of firm performance by 8.2%. The same is observed with model IV which has human capital variables compared to model III but the significance level increases to 1%. Similarly, the model V, which captures the effect of social capital variables and access to finance explains the productivity of the firms significantly better than model IV (F Change = 2.644 at p=.001).

Table 4.15: Regression results explaining innovation input-output-performance relationship

Dependent variable: Value-added per worker

Independent variables	MODEL I	MODEL II	MODELL III	MODEL IV	MODEL V	MODEL VI
(Constant)	3.167***	3.068***	2.663***	2.416***	2.365***	2.330***
	(0.267)	(0.230)	(0.441)	(0.443)	(0.387)	(0.421)
CAPITAL	0.481***	0.472***	0.217**	0.291**	0.324**	0.386***
	(0.223)	(0.077)	(0.486)	(0.733)	(0.421)	(0.08)
CAP_UTILZ	1.413***	1.387***	1.287**	1.167***	1.373**	1.311**
	(0.784)	(0.626)	(0.772	(0.526)	0.556	(0.692)
LABOUR/SIZE	0.253**	0.165	0.223	0.226	0.279	0.286
	(0.094)	(0.110)	(0.114)	(0.119)	(0.121)	(0.121)
AGE		0.134	0.114	0.140	0.132	0.142
		(0.124)	(0.112)	(0.112	(0.104)	(0.107)
EXPORTER		0.270***	0.129**	0.137**	0.127	0.133**
		(0.094)	(0.088)	(0.089)	(0.110)	(0.088)
FOREIGN		0.268**	0.282***	0.301***	0.274**	0.187*
		(0.117)	(0.105)	(0.108)	(0.104)	(0.111)
RDD			0.202**	0.184**	0.176*	0.181**
			(0.082)	(0.082)	0.084	(0.081)
RDRATIO			0.118	0.197**	0.184*	0.178*
			(0.079)	(0.083)	0.098	(0.077)
COMPUTER			0.196**	0.184**	0.163*	0.152**
			(0.092)	(0.094)	(0.092)	(0.094)
WEBUSE			0.286**	0.281**	0.277**	0.272**
			(0.112)	(0.110)	0.109	(0.108)
TECHAQU			0.272**	0.302**	0.279**	0.286**
			(0.119)	(0.128)	0.123	(0.124)
DEGREE				0.023	0.126**	0.129**
				(0.037)	0.066	(0.055)
PROFSHA				1.399**	1.213**	1.253**
				(0.611)	(0.609)	(0.604)
TRAINING				0.110	0.156	0.145*
				(0.084)	(0.141)	(0.085)
COMP					0.137**	0.117**
					(0.055)	(0.048)
UNIVERT					-0.143	-0.098
					(0.157)	(0.114)
CUSTOM					0.325***	0.295***
					(0.111)	(0.098)
SUPPLER					0.068	0.021
					(0.126)	(0.091)
CREDIT					0.099	0.138
					(0.097)	(0.087)
INNOVAT						0.189**
						(0.096)
Adjusted R^2	0.337	0.397	0.442	0.492	0.542	0.618
Incremental F-test	17.083***	6.504***	2.727**	4.423***	2.644**	3.352***
R^2 Change	0.337	0.181	0.082	0.150	0.085	0.095

Source: Author

Note: *Significant at 10% level; ** significant at 5% level; *** significant at 1% level. Figures in parenthesis indicate standard errors.

The combined effect of social capital variables and access to finances increases the explanatory power of the model by 15% controlling for the effects of productivity inputs,

firm characteristics and technological factors. The final global test shows that the addition of innovation variable significantly improves explaining power of the model (F Change = 3.352 at p=.001).

These global tests indicate the need to consider firm specific characteristics, technological, human capital, and social capital and innovation factors together in order to better explain the performance technology-based firms. On the basis of adjusted R^2, the full model (model VI) explains 61.8% variation of firm performance which is significantly better compared to other models. Consequently, the individual impact of each variable is discussed here based on the specification of model VI.

Starting with model I, the results show that capital stock, capital utilization and labour are important variables to explain performance of the firms as measured by value-added per worker. The findings indicate an elasticity of output with respect to capital and labour of 0.481 and 0.253 respectively, and a scale elasticity of 1.413 which are all significant at least at $p<.05$.

This shows increasing returns to scale with an increase of 10% of capital stock and capital utilization contributing to around 4.8% and 14 % increase on value-added respectively. However, the sum of the coefficients of capital and labour in the estimated equation is 0.734 which is less than 1 indicating lack of constant returns to scale for Kenyan technology-based firms. This suggests that there are considerable unexploited economies of scale by the firms.

Once technological, social, human capital and demographic variables are controlled for as shown in model VI, the elasticity of capital and capacity utilization drops to 0.386 and 1.131 respectively but still remain significant at least at $p<0.05$. The basic model explains 33.7% of variance in firm performance which show that capital stock, labour and capital utilization capacity are key determinants of performance of TBFs in Kenya.

All the variables capturing the firm characteristics as proxied by firm age and market orientation are all positive but only FOREIGN and EXPORTER dummy are significant at least at 10% level. Though not significant, the positive coefficient on the firm age variable may be capturing learning by doing which increases firm productivity over time. The positive coefficient associated with foreign dummy, indicates that firms that have links to foreign sources of technical knowledge do better than domestic firms. Though the size of the firm, taken as proxied by logarithm of employment (labour) was seen to have positive and significant effect on R&D and innovation equations, its effect is not significant with regard to the productivity equation. Typically, in descriptive analysis one usually finds a positive relationship between size and the three dimensions (Correa et. al., 2005 but in this case the effect of size appears to disappear in the R&D and innovation equations. Thus it can be concluded that, size is an important determinant of productivity of TBFs in Kenya only through R&D-innovation propagation.

With regard to innovation input variables, RDD, RDRATIO and TECHACQU are all significant. This indicates that firms which acquire technology in either embodied or disembodied form or engage in R&D activities and invest in them are more productive

than firms which do not engage in those activities. The innovation output variable (INNOVAT) is also positive and significant ($p<.05$) as expected. Ceteris paribus, when value-added per worker is compared between firms that introduced process/product innovations and those that did not, the findings show that those firms that introduced the innovations are almost 19% more productive. The comparison of the effect of RDRATIO and INNOVAT on firm performance contradicts the main hypothesis underlying the model that it's not the innovation input (R&D) but innovation output that affects the productivity of a technology-based firm. While investment in R&D did not increase the probability of the firms to innovate as indicated in the previous section, these results show that investment in R&D has direct positive effect on firm productivity. Thus it can be concluded that, investment in new knowledge through R&D affects the productivity of TBFs in Kenya directly other than indirectly through innovation propagation.

The coefficients associated to computer use and web-use have positive signs as expected and are statistically significant. These variables are interpreted as proxies for technology adoption within the firm and organizational and managing capacity, suitable for the assimilation, improvement and exploitation of existing information (Correa et. al., 2005). The results show that if the share of workers using computers was 10% higher in absolute terms, then the value-added per worker in relative terms will increase by approximately 1.5% while those firms that uses the web to do business with suppliers/customers would have their productivity increase by approximately 2.7%.

Turning to the impact of human capital variables on performance, the Table indicates a positive relationship between training and firm value-added. The coefficient of TRAINING dummy is positive and significant at 10 % level. This points up to the potential benefits that can be gained by the firms from increasing the competence levels of the workforce through either formal or informal training. The quality of management as reflected in the formal education of the management (DEGREE) and the labour skill as proxied by the professional share in labour (PROFSHA) also turn out to be significant in influencing the firms' productivity at least at $p<.05$. The coefficient of PROFSHA indicates that a 10% increase number of skilled professionals would increase the productivity of the firms by 12.5%. The variable PROFSHA was also found to be significant in the R&D specification examining the determinants of R&D intensity of a firm, that of technology acquisition and that of innovation equation (See section 4.8, 4.9 and 4.10 respectively). This shows that the skills of the workforce is a predictor of four dimensions under study, i.e., technology acquisition, R&D, innovation and productivity. It also indicates that PROFSHA influences firm performance either partially or through its influence on innovation.

The social capital variables indicate that interactions with other enterprises (COMP) and customers (CUSTOM) have a significantly higher value-added per worker. Being a member of this network seems to be very important for the firms. Various reasons could be invoked to explain the benefit of this networking effect: access to information, increased bargaining power with government and foreign competitors, and exploitation of synergies. Similarly, firms which have access to external financial funds (CREDIT) have

a higher TFP. Though the causality between access to finance and productivity is not very clear in this regression, it is an interesting finding with important policy implications. Financial constraints are often perceived to be significant determinants of firm performance and growth.

In summary, comparing the four models that answers the broader question about understanding the relationship between investment in research, innovation and productivity the results shows that firms that invest in technology acquisition are more innovative than those that invest in in-house R&D. Thus, it appears that the channel through which TBFs in Kenya improve their innovative performance is mainly through investment in external technological efforts through technology acquisition and not investment in research and development. These results notwithstanding, firms that invest in knowledge in terms of R&D and technology acquisition and those that launch innovations in the market with or without the influence of the innovation inputs (R&D and technology acquisition) perform better than competitors who don't. Thus the effect of R&D on firm productivity is direct while the effect of technology acquisition is both direct and indirect through innovation propagation. Introducing innovations in the market also individually stimulates higher firm performance. This complex input-output relationship is explained by the new knowledge paradigm that proposes the possibility of occurrence of innovation without research, (Cowan & van de Paal, 2000), based on "the recombination and re-use of known practices", as David and Foray point out (1995) and the dual nature of R&D as suggested by Cohen and Levinthal (1989), where a minimum level of R&D investments is a needed to develop the firm's ability to identify, adapt

(innovate), and exploit external knowledge which enhances firm performance. Thus the hypothesis that, states "it is not innovation input that affects firm productivity but innovation output" is rejected, at least for Kenyan technology-based firms.

4.11 Chapter summary

This chapter dealt with the three questions that sought to establish the importance of various sources of knowledge in explaining the relationship between investment in new knowledge, innovation and productivity of the firms during the period 2004-2006. A number of technological, human capital, social capital and firm-level specific variables drawn from the survey were econometrically related to measures of technology acquisition, R&D, innovation and productivity. The major findings include the importance of human capital as a predictor of the four dimensions under study. The results showed that the impact of social capital in the new knowledge – innovation-productivity nexus is multifaceted in its effect. The innovative performance of the firms appears to be influenced significantly by technology acquisition than R&D effort. However, firms that had higher R&D intensity and innovated performed better than those that did not. Detailed summary of the major findings, conclusions and recommendations are presented in the next chapter.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The main objective of this study was to establish the determinants of performance of technology-based firms in Kenya by investigating the influence of technological business practices, human capital, social capital and firm-level characteristics on knowledge acquisition through R&D and technology acquisition, innovation and performance. In this chapter some of the results of are reviewed to discuss possible policy implications and recommendations. The list of issues does not aim to be exhaustive nor does it imply any prioritization. Rather, it summarizes the main policy implications that emerged from the empirical analysis and should be seen as considerations to be taken into account in the exercise of policy-making. The chapter starts with the summary of major findings drawn from the study. It is followed by conclusions drawn out of the findings and possible policy recommendations born out of the empirical investigation.

5.2 Summary of findings

Objective (a) dealt with business practices that reflect innovative capability of firms. The following summary of findings can be made: First, most of the innovations that occurred within the firms during the study period were incremental as evidenced by non-existent of patents in five out of seven industries surveyed. Technological innovation performance was largely inadequate as evidenced by low investment in R&D and low level of specialized human resources. Second, firms that were integrated more in the international markets, i.e., foreign owned or has exporting experience performed better than the local counterparts in virtually all dimensions measuring innovative capability i.e. introduction

of innovations, establishment of innovation networks, use of qualified labour force and R&D efforts undertaken. Large firms exhibited similar performance like the exporters and foreign firms in many respects but notable differences existed in the intensity of R&D efforts undertaken. Small firms invested more in R&D activities per worker than large firms. Third, both innovators and unsuccessful innovators acquired innovative capability primarily through acquisition of technology embodied in machinery and equipment and that innovators used tooling up and industrial design more than R&D activities in acquiring the innovative capability. Fourth, all firms faced similar obstacles to innovation which were: lack of customer responsiveness, high costs of developing new or significantly improved products or processes, lack of financing for conducting R&D activities and undeveloped national system of innovation. Fifth, with human resources issue – innovators or not - preferred using the informal learning system (training and hiring experienced workers) instead of the more formal education system (hiring from university, technical institutes or colleges).

5.2.1 Summary of findings for econometric estimations

The summary of econometric estimation for the four dimensions that was hypothesized to determine the performance of the firms is indicated in Table 5.1 below. The Table presents a brief summary containing qualitative information on the parameter estimates. Positive (+) and negative (-) signs represents significant positive or negative effect of the independent variable on the corresponding dimension respectively. NS indicated against the sign represents non- significant effect of the variable on the corresponding dependent variable but the effect of the variable was worthy of note in this study.

Table 5.1: Qualitative summary of major findings

Determinants	*Technology adoption*	*(R&D) Selection equation*	*R&D intensity*	*Innovation*	*Productivity*
Capital stock	+				+
Capital utilization					+
Demographic variable					
Age effect	-				+ (NS)
Size effect	+	+		+	
Exporter effect	+ (NS)	+	+	+	+
Foreign effect			-	+	+
Technological variables					
R&D activities					
R&D Intensity effect	+				+
Innovation effect					+
Technology acquisition effect				+	+
Computer effect					+
Web use effect					+
Human capital variables					
Manager has a university degree effect	+	+	+	+	+
Professional share in labor			+	+	+
Training effect	+ (NS)			+	+
Social capital variables					
Linkages with other enterprises effect					+
Linkages with suppliers effect	+				
Linkages with customers effect				+	+
University linkage effect					
Others					
Credit effect		+	+		+

Source: author

Determinants of innovation input

The second objective sought to examine the determinants of investment in new knowledge through technology acquisition and R&D by TBFs in Kenya. The following are the major findings drawn from the study.

a) Determinants of technology acquisition

The following factors significantly increased the probability of the firms to invest in new knowledge through technology acquisition: Firm size, qualified managers, level of certified engineers and scientists, firms that are export oriented; general social capital;

R&D intensity, training linked to innovation, capital stock and accessibility to credit. These findings indicate: i) that smaller firms are at a disadvantage in acquiring new knowledge through technology acquisition, ii) that larger firms coupled with richer stock of human capital give TBFs in Kenya an edge in innovativeness through technology acquisition, iii) that R&D and training are required as complimentary investments to acquisition of technology, and iv) that credit constrained firms may find it hard to finance acquisition of new technology. This finding suggests that, for Kenya to attain levels of technology modernization, a broader set of measures to support technology acquisition and for SMEs in technology-based industries is important.

b) Determinants of R&D decision and R&D intensity

The study showed that the determinants of conducting R&D and those of R&D intensity were partially different. In particular, educational background of the manager had significant effects on the R&D intensity of the firms, but not on whether they conducted R&D, while firm size had significant effects on the decision to conduct R&D activities and not how much they invested in them. Similarly, the share of professionals affected the decision on whether or not to engage in R&D but not R&D intensity. Access to finance, had positive effects on both the decision to conduct R&D and how much to invest in it.

One implication of these results is that policy-making objectives—on whether to increase the number of innovative firms or the intensity of innovation—affect the type of support measure to be used. For example: if the decision is to increase R&D activities of the firms, one important measure is to promote qualified human resources by hiring of

"trained and certified specialists," as only increasing a firm's R&D expenditures is unlikely to make it innovate. The second implication relates to firm size. The finding that the smaller the firm, the lower the probability of engaging in R&D activities, implies that small firms are at a disadvantage against large firms due to factors that prevent them from engaging in those kinds of activities. To remove the obstacles which may be preventing SMEs to engage in innovation activities is, thus, a key area for policy-makers.

c) Determinants of innovation output

The major finding relating to determinants of innovation output include the following: i) Innovation input relating to R&D investments does predict the probability of TBFs in Kenya to introduce innovations; however investing in technology acquisitions predicts the probability of introducing innovations. ii) Only networks with customers increase the probability of innovating, iii) networks with universities and scientific institutions do not increase the probability of transforming innovation input into innovation output, iv) larger firms were more prone to successfully introduce commercial innovations

These findings indicate TBFs in Kenya increase their innovative performance manly through external technological efforts through technology-acquisition and that the firms' investment in internal technological efforts through R&D does increase the probability of introducing commercial innovations. The findings also indicate that small firms are at a disadvantage in transforming new knowledge into innovation output compared to larger firms. The absence of significant effect of collaboration with universities suggests the innovations were incremental as opposed to radical.

d) Determinants of performance

Results for direct and indirect effects of the variables on firm performance are summarized below.

i) All human capital and firm specific characteristic variables have direct positive effect on the economic performance of the firms measured in labour productivity, ii) the intensity of R&D affect firm performance directly without influencing innovation outcome, while the effect of TA is both direct and indirect through innovation propagation, iii) Social capital variables have multifaceted effect: network with customers and competitors significantly increased value-added while networks with suppliers and universities did not, iv) Generally firms that had competent workforce, engaged in R&D and technology acquisition, introduced innovation, and are integrated in international markets are more productive. Thus, since R&D, technology acquisition and innovation output contributed to higher performance levels than competitors which did not innovate, public policies geared towards R&D promotion and technology acquisition should have positive results in terms of the overall performance of the firms.

5.3 Contribution of the study to theory and the existing body of knowledge

This study provided several theoretical and practical implications for researchers and managers who are concerned with technology-based firm performance. Managers of innovative enterprises seldom attribute social capital factors as significant determinants of firm perforamance (Dollinger, 1995). However, the study confirmed (showed) the

importance of social capital theory along with resource- based theory in developing innovative capabilities of the firms and in explaining firm performance. External linkages established by firms were as important as technological, physical, and human capital in determining organizational performance in the context of technology-based ventures. The analyses also confirmed most of the theoretical and empirical predictions advanced in the literature about the relationship between investment in knowledge, innovation and productivity. It emerged from the analyses that firm characteristics remained as crucial variables for developing new technologies, to realize innovations and to improve firm productivity. Larger firm size coupled with a richer stock of its human capital base and wider social capital was found to give a potential edge to firms to become more innovative. Moreover, a greater investment in R&D was also seen to greatly enhance the acquisition of new technology. The results strongly support the hypothesis that greater internal and external resources enable the firms to better innovate in the economy and become more productive. The results thus generally confirm the conventional wisdom about the determinants of performance of technology-based firms but contextualized into Kenyan technological, cultural and economic uniqueness.

Second the study built up a picture of the typical technology-based firm in Kenya and the business practices that contributes to its innovative performance. It contributes to the literature by identifying in a preliminary way the types of firms that are at a disadvantage in building up innovative capability and barriers and success factors to stimulate the capability to generate new knowledge in the Kenyan context. While it is possible to learn

from global pool of knowledge about success factors and constraints to overcome in building innovative capability, the lessons need to be tailored to socio-economic and technological uniqueness of individual countries (Kesidou, 2009).

Third, the study provided a further test on the empirical validity of RBV and social capital theory on competitive advantage and firm performance - a validity that required further scrutiny as much of the pertinent literature was largely conceptual particularly in developing countries. With a few exceptions, the previous literature on techno-entrepreneurship development has been based on western countries, particularly USA, Germany, Japan, Britain, yet as Kesidou (2009) argues generalization of entrepreneurship theories in one culture or nation to other cultures or nations does not provide situational analysis required for techno-entrepreneurship propulsion.

Fifth, econometric model dealt with the estimation of five equations, to explain the link between the investment in new knowledge, innovation and firm performance. The contributions of this modeling to technology-based firm performance literature are on many dimensions:

i) The model approach captures the direct influence of human and social capital factors on innovation input, innovation output and firm productivity. Other studies have tried to understand this effect on productivity indirectly through innovation output propagation. The findings of this study indicate technology based firms in Kenya can be innovative without investing in R&D and that R&D increases firm performance directly and not

indirectly through innovation propagation. This finding adds to the theory of absorptive capacity (Cohen and Liventhal, 1989) where a minimum level of R&D investment is needed to identify, adapt and exploit external knowledge that increases firm performance and the new knowledge paradigm (Cowan & van de Paal, 2009) that posits that there can be occurrence of innovation without research.

ii) It adds to the Schumpeterian hypothesis, with respect to the relationship between innovation and firm size, (Acs & Audretsch 1988; Cohen & Klepper 1996). The findings of this study indicate that the of intensity of investment in R&D is not only a preserve of large firms as Schumpeterian hypothesis posits at least for TBFs in Kenya.

iii) Novel measures created to assess the effect of partner diversity on innovation input, output and firm productivity contributed significantly to network literature (Baumal, 2000).

5.4 Conclusion

This study concludes that investment in new knowledge through R&D and technology acquisition and transforming the new knowledge into commercial innovations significantly determines the performance of technology-based firms in Kenya. The study showed that, TBFs in Kenya that invested in R&D activities and technology acquisition and launched new or improved products/processes to the markets performed better than those that did not. However, the underperformance of the firms in the global stage is explained by low innovative performance as evidenced by low investment in R&D, low

level of specialized human resources and lack of significant contribution of universities and scientific institutions in enabling the firms launch commercial innovations. Thus it appears that investment in R&D directly contributed to higher firm performance during the study period by increasing the 'absorptive capacity' and not indirectly through innovation propagation as the main hypothesis posited, at least for Kenyan technology-based firms. The lack of transformation of knowledge generated through R&D and the level of investment in in-house R&D does not make the firms innovative that stops them from capturing specialized niches in the world's leading markets. Factors that determine the performance of the firms by influencing investment in new knowledge, innovation and productivity include: human capital factors (education of the manager, level of engineers and scientists in the firm, training linked to innovation; social capital factors (networks with competitors, customers and universities); and firm specific characteristics relating firm size and international market integration through exporting.

5.5 RECOMMENDATIONS

5.5.1 Recommendations for practice

The study showed that for technology-based firms in Kenya to increase their performance through enhanced productivity, several factors must be considered. Hence the study advocates for a comprehensive set of policies. The emerging policy implications can therefore be outlined as follows:

First, the finding that technology acquisition increased the probability of the firms to be innovative and to be more productive requires special policy attention. This is also

necessary in the light of the importance of the acquisition of embodied technology to firm-level innovativeness as reported by the firms. Small firms were also at a disadvantage in developing the capacity for adopting new technology. Thus for Kenya to attain levels of technology modernization, a broader set of measures to support technology adoption and for SMEs in technology-based industries is important. This study proposes that the government formulates an industrial and technological policy that considers tax breaks for technology acquisition by Small and Medium technology-based firms. It also recommends that the government strategically removes import barriers of capital goods, technology, machinery and equipment that could serve as sources of learning and capability development through imitation, replication and reverse engineering.

Second, the interactions with other firms and institutions in general appeared to be a significant predictor of the firms to develop the ability to acquire technology and perform R&D activities. Linkages with customers and other firms appeared to significantly influence innovation out comes as well as firm productivity. However, links with universities had no significant impact on either innovation outcomes or the productivity of the firms. Policies to encourage university-industry links through collaborative R&D and training activities will enable universities to conduct research and other activities, which are more relevant to industry. For universities to able to contribute in technology-based development, appropriate supporting institutions are necessary. The study proposes that the government devise enabling polices and organizations that can increase the pathways of interaction between universities, industry, customers, and suppliers. Specific

measures could include establishing business incubation and technological parks and centers within or near universities like what has been done in developing countries. It would also be necessary for the government to enact an innovation law that provides the legal basis for (i) the transfer of research results to the private sector (ii) the appropriation of the financial returns from discovery by researchers and the research centers. Additional provisions should facilitate the use of research public facilities by the private sector. These provisions are likely to increase productivity of public research and increase the transferring of knowledge to the private sector.

Third, policies need to be formulated to enhance scientific and technical human capital accumulation. The finding that both the educational level of the manger and the share of certified specialist in science and engineering significantly influenced the occurrence of technology acquisition, R&D activities, introduction of innovations and firm productivity underscores the importance of human capital in the technological modernization and creation of competitive advantage by the firms. Overall, TBFs in Kenya appeared quite similar to firms in other countries with respect to the importance of human capital as a determinant factor of technological progress and firm performance. However, where Kenyan firms differed from their Asian and Latin American counterparts is the level and quality of human capital endowment. The finding that the firms preferred using the informal learning system (training and hiring experienced workers) instead of the more formal education system (hiring from university, technical institutes or colleges) for their innovation efforts confirms the low confidence the firms have in the quality of human resources churned out of the Kenyan education system. Thus, broader government

policies should be formulated that would increase the supply of qualified personnel. This study proposes that the government reforms its policies towards education in science and engineering with a view to increasing enrolment, design institutions that will enable the country to use the skills developed nationally to avoid brain drain and devise a mechanism of deepening efforts inside the firms that would promote learning, such as on-the-job training and R&D activity. Effective and demand driven programmes should be developed by the Kenyan higher education institutions so that the graduates released to the market are able to meet the technological demands of the industries. R&D at firm and industry level should also be encouraged and facilitated. This could be done by devising an incentive scheme, like starting a science, technology and innovation fund.

Fourth, participation in exports should be encouraged as that would force domestic firms to learn and increase their technological effort in order to compete effectively in the global market.

Fifth, this study showed that there were very strong effects of internal resources and external resources in explaining the relationship between investment in new knowledge, innovation and productivity. Some prior research tried to prove the importance of external linkages, and others investigated the effects of internal firm resources and capabilities on organizational performance. In other words, most of prior studies on new technology-based ventures investigated the impact of internal resources and capabilities and social capital on performance separately, but this study suggests that two theories need to be complementary considered and integrated. The results of this study suggest

that the entrepreneurs of technology-based ventures should simultaneously develop internal innovative capabilities and social capital.

Lastly, even though large enterprises were more prone to transform knew knowledge into commercial innovations, it does not mean that innovation is a prerogative of this type of firms. Innovation is also a goal for the smaller enterprises – in fact small firms invested more into innovation activities per worker than large firms as this study has found out. Thus, probably the entrepreneurial innovation process will have to be faced in another way, different from the way large enterprises approach it. Small and medium firms have limitations caused by their dimension particularly with regard to human capital and social capital as indicated by the findings of this study. Cleary, in the scope of innovation, it is urgent to overcome these restrictions through resources accessible to all firms. But, more specifically, concerning the hindrances that smaller enterprises have, they should be able to establish relationships with external partners, regarding innovation, in order to surmount their weaknesses and to access the resources and capacities they need to develop innovative activities. As a result, smaller enterprises will be able to innovate in their processes and products. To achieve this, smaller firms should be aware of their own shortcomings, and they also have to know the resources at their disposal, in order to overcome their limitations. In this area, there are several intervening entities and institutions that are responsible for stimulating innovation and for creating a truly innovative system, capable of maximizing an innovative environment.

5.5.2 Recommendations for further research

Regarding the research agenda, to learn more about the determinants and impacts of the innovative behaviour of Kenyan-technology-based firms and its impact on firms' performance, the following issues are important:

i) Since the number of firms that declared to be innovators seemed to be a bit high, more research is needed on the scope and quality of the innovations introduced by the firms. The study suggests that the quality of the innovations could be investigated by looking at whether the innovations were minor, major or radical and establish the link between the innovations introduced and patent acquisition.

ii) This study was limited to only studying product and process innovations. Other types of innovations like; marketing, organizational and management innovations introduced during the period of study may have influenced firm performance but their effects are not captured in this study. Future research should take account of this when studying innovation capability and firm performance.

iii) The obstacles to the innovation, which seemingly affected more intensely the SMEs, should be examined, paying special attention to the role of the access to financial resources and technology acquisition.

iv) During the period under analysis (2004-2006), a number of policies were introduced in order to foster innovation activities in the private sector. Learning about the impact of those policies would be relevant in order to improve on them.

v) Given the fact that in the study innovators had a better performance in terms of value-added than non-innovators, it would be equally important to quantify the impact of the introduction of new products and processes on employment creation and productivity growth. In addition, it would be relevant to learn to what extent export performance can be explained by the intensity of innovation inputs and outputs.

vi) The study focused on understanding the determinants of performance at industry level and not the sector level. Since different sectors face different technological opportunities, studies focusing on the sectors and analyzing them separately, would take into account the sector specific nature of technological capability and innovation. Thus studies focusing on sectors would give insights into the sector specific characteristics and driving forces of productivity of individual sectors that characterize technology-based cluster of the manufacturing industry.

vii) The study focused on the formal inter-organizational relationships in investigating the impact of social capital on firm performance. Future research needs to consider informal inter-organizational relationships such as entrepreneur's and founding team's personal networks which could reveal the dynamics of external resource mobilization through both formal and informal networks and furnish comprehensive results about external resource mobilization of capabilities.

viii) This study investigated only partnership-based linkages or interactions but did not investigate the relationships between sponsorship-based linkages on innovation and firm performance. Sponsorship-based linkages of an organization are unilateral relationships in the sense that external entities provide supports to the organization without receiving explicit rewards. These linkages are forged between firms and venture capitalists, business angels and other third parties. They provide external resources and capabilities that the firms would otherwise not get through internal efforts. Understanding the role played by these networks in innovation and performance is important.

ix) It would also be interesting to conduct similar studies in other sub Saharan countries applying the analytical framework developed. Similarly, other developing and technically backward countries from the rest of the world can also be studied for international comparisons.

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APPENDICES

APPENDIX A

LETTER OF INTRODUCTION

Kaburu F. Kinoti
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Tel. 810901-19 Ext. 57342
Email: kaburukinoti@yahoo.com

The General Manager/managing director
ABC Ltd.
P.O. Box
Nairobi

Dear Sir,

I would like to take this opportunity to request if you would be interested to participate in this nationwide survey on technology based firms (TBFs) conducted by Department of Business administration of Kenyatta University.

Historically business research and teaching in Kenya has focused on small sized and low technology-based businesses in the informal sector and large business in the formal sector. As a result owners of business in these sectors can draw a wealth of information accumulated over the years to help them in running their firms. Unfortunately, this wealth of information has little applicability to high technology based or innovative firms such as yours. The needs of small, medium and large sized technology-based firms such as yours have been overlooked for a long time.

To address this oversight, I need your help. Your firm has been selected as a member of a sample in Nairobi area to participate in a research project to advance our understanding of socio-economic determinants of techno-entrepreneurship and the extent to which TBFs face important constraints in raising productivity in Kenya. Thus, I would so much appreciate your acceptance to participate in this study. Please indicate your acceptance by replying to the above postal or e-mail address. A self addressed postage paid envelope has been enclosed for your convenience. Upon your acceptance you will be visited at your offices and assisted to fill out a questionnaire that will last between 15 to 25 minutes.

Please keep several things in mind: (1) your participation is very important to the success of this project (2) all responses are STRICTLY CONFIDENTIAL (3) Your participation in this project will be beneficial to your organization (4) the recommendations of this study shall be used to enhance our advisory work to the Kenyan government and international agencies including World Bank and (5) you will receive a copy of the executive summary of the project upon completion.

Thank you for your help. I look forward to receiving your response.

Best regards,

Kaburu F. Kinoti
Principal Researcher

APPENDIX B

SURVEY QUESTIONNAIRE

SERIAL NUMBER_____

HEADER

Respondent, please complete:

Name (optional):_____ Firm Name:_____ Position:_____

Tel: _____ E-mail:_____ Fax:_____

PART 1- To be completed by principal manager

A. GENERAL COMPANY INFORMATION

1. Address: _____ City: _____Code |____|____|____|____|

2. Year of establishment: |____|____|____|____|

3. Firm size ☐ Small ($\geq$ 10and $\leq$ 49 employees) ☐ Medium ($\geq$ 50 and $\leq$ 149 employees)

☐ Large ($\geq$ 150 employees)

4. Legal form: ☐ Sole proprietorship ☐ Partnership ☐ Publicly listed company

☐ Privately held limited company

☐ Others (please specify) _____ _____

5. Main sector of Activity:

	Manufacturing	Services
Chemical and allied	☐	☐
Pharmaceuticals	☐	☐
Plastics	☐	☐
Electrical and electronics	☐	☐
Auto and auto parts	☐	☐
Metal and Machinery	☐	☐
Optical and medical equipment	☐	☐
Other (pls specify) _____	☐	☐

6. How many establishments (separate operating facilities) does your firm have in this country? |____|____| *(an operating facility is defined as a productive unit geographically different from other units. A product line per se does not constitute an operating facility)*

7. In what year did this establishment begin operations in this country? |____|____|____|____|

8. What percent of your firm is owned by?

(a) State/Government |____|____|____| **%**

(b) Domestic |____|____|____| **%**

(c) Foreign |____|____|____| **%**

(d) Other (specify)_____ |____|____|____| **%**

9. In the fiscal year 2006, what percentage of this firm's exports were: (indirect exports are sales made domestically to a third party that exports)

(a) National sales |____|____|____| **%**

(b) Indirect exports |____|____|____| **%**

(c) Direct exports |____|____|____| **%**

10. **Select the appropriate definition of your establishment**. *(**Start-up** refers to a fully independent new company. **Spin-off** Company is an incorporated commercial entity that derives a significant portion of its commercial activities from the application or use of a technology and know-how developed by or during a research program within a firm or university).*

☐ *Start-up* ☐ *Corporate Spin-off* ☐ *University spin-off* ☐ *Other (specify)*_____

11. Age: |____|____|

12. Gender: ☐ *Female* ☐ *Male*

13. Marital status: ☐ *Single* ☐ *Married* ☐ *Separated*

14. Are you founder member of your firm? ☐ Yes ☐ No

15. Highest education level obtained by you:

☐ Ordinary Diploma ☐ Higher diploma ☐ 1st university degree

☐ Masters ☐ PhD/Doctorate ☐ Other (specify)_____

C. TECHNOLOGY ACQUISITION, ADOPTION AND INNOVATION NETWORKS

16. In the last three fiscal years has your firm acquired a technology that significantly changed the way the main product is produced? (*Acquisition includes introduction of machinery and equipment with improved technological performance, the acquisition of external technology in the form of patents, non-patented inventions, licenses, disclosures of know-how, trademarks, designs, patterns and computer*).

Yes ☐ No ☐

If yes estimate the cost of the technology Ksh_____

17. What percent of your total workforce regularly uses a computer in their jobs? |___|___|___|%

18. Does this firm regularly use the web or internet to communicate with suppliers or customers?

☐ Yes ☐ No

D. INNOVATION ACTIVITIES, SUCCESS FACTORS, OBSTACLES AND INNOVATION NETWORKS (*Innovation activities are all those steps necessary to develop and implement technologically new or improved products or process)*

19. Does your firm engage in the following innovation activities?

a) Research and development within the enterprise. ☐ Yes ☐ No

b) Acquisition of machinery and equipment ☐ Yes ☐ No

c) Tooling up and production start-up. ☐ Yes ☐ No

d) Training directly linked to technological innovation. ☐ Yes ☐ No

e) Industrial design, other production preparations for technologically new or improved product ☐ Yes ☐ No

20. How much did your plant spend on design or R&D in 2004? Ksh _____ (***Spending*** *includes wages and salaries of R&D personnel, such as scientists and engineers; materials, education costs, and subcontracting cost*).

21. Between 2004 and 2006, did your enterprise introduce new or improved product, new not only to your enterprise but also to your enterprise market?

☐ *Yes* ☐ *No*

22. Between 2004 and 2006, did your enterprise introduce new or improved process, new not only to your enterprise but also to your enterprise market?

☐ *Yes* ☐ *No*

23. Between 2004 and 2006, did your enterprise try to introduce new or improved product or process but failed?

☐ *Yes* ☐ *No*

24. Did your enterprise apply for at least one patent between 2004 and 2006 in any country?

☐ *Yes* ☐ *NO*

25. Please indicate the level of importance of the following factors in introducing new/improved product or process innovations in your firm *by placing a check mark in the appropriate box)*	**Very important**	**Important**	**Moderately important**	**Slightly important**	**Not relevant**
1. Satisfying existing clients.	☐	☐	☐	☐	☐
2. Training employees.	☐	☐	☐	☐	☐
3. Promoting firm or product reputation.	☐	☐	☐	☐	☐
4. Seeking new markets.	☐	☐	☐	☐	☐
5. Hiring experienced employees.	☐	☐	☐	☐	☐
6. Developing niche or specialized markets.	☐	☐	☐	☐	☐
7. Developing export markets.	☐	☐	☐	☐	☐
8. Performing R&D activities.	☐	☐	☐	☐	☐
9. Frequency of contacts with other agents	☐	☐	☐	☐	☐
10. Hiring new graduates from universities and other colleges.	☐	☐	☐	☐	☐

26. Do you think the following factors present an obstacle to your firm to introducing new/improved product or process in your firm? (*Indicate the severity of obstacle by placing a check mark in the appropriate box)*	**Very severe obstacle**	**Major obstacle**	**Moderate obstacle**	**Minor obstacle**	**No obstacle**

1. Lack of financing	☐	☐	☐	☐	☐
2. High cost of developing innovations.	☐	☐	☐	☐	☐
3. Inability to devote staff to projects.	☐	☐	☐	☐	☐
4. Lack of skilled personnel.	☐	☐	☐	☐	☐
5. Undeveloped national system of innovation.	☐	☐	☐	☐	☐
6. Organizational rigidities.	☐	☐	☐	☐	☐
7. Lack of cooperation with other firms.	☐	☐	☐	☐	☐
8. Lack of research and development at industry.	☐	☐	☐	☐	☐
9. Cost of registration of intellectual property rights	☐	☐	☐	☐	☐
10. Public funds available for R&D.	☐	☐	☐	☐	☐
11. Lack of marketing capabilities.	☐	☐	☐	☐	☐
12. Lack of external support.	☐	☐	☐	☐	☐
13. Lack of networks around industries.	☐	☐	☐	☐	☐
14. Lack of access to relevant technology.	☐	☐	☐	☐	☐
15. Government regulation affecting technology.	☐	☐	☐	☐	☐
16. Lack of customer responsiveness.	☐	☐	☐	☐	☐
17. Lack of access to expertise in the university.	☐	☐	☐	☐	☐

27. Please indicate whether or not your firm had any co-operative arrangements on innovation activities with the following agents or institutions during the period 2004-2006 by ticking against the appropriate box

Agent/institution	Yes	No
Universities		
Suppliers		
Competitors		
Customers		
Consultants		

PART 2: WORKFORCE STASTITICS AND FIRM PRODUCTIVITY

E. LABOUR AND HUMAN RESOURCES. This section to be administered to human resource manager

Please use the following definitions in this section.

Management: *Persons making management decisions. Please exclude those involved only in shop floor supervision.*

Technical Professionals*: Trained and certified specialists outside of management such as engineers, chemists and other scientists.*

Other professionals: *Support, administrative, accountants, sales workers not included in management or among the technical professionals.*

Skilled Production worker: *Those person involved in production processes or direct or supervision of such processes and whom management considers to be skilled (e.g. technician, technologists etc*

Unskilled Production worker: *Persons involved in production processes but whom management considers to be unskilled e.g. factory workers.*

28. Please indicate the number of permanent and full-time employees employed by you as at the end of the year 2006 (or any other relevant reporting time) _____

29. Of the full time employees as at 2006, how any were_____? Fill the table below.

Type of employee	Total number of workers
Management	
Technical professionals	
Other professionals	
Skilled production worker	
Unskilled production worker	

30. What percent of the workforce at your establishment have the following education levels?

a) Some university education |___|___|___|%

b) Vocational/technical education |___|___|___|%

c) Secondary education |___|___|___|%

d) Primary education |___|___|___|%

e) None |___|___|___|%

F. PRODUCTIVITY. To be administered to the company accountant. *The purpose of the section is to allow an estimate of the productivity of firms like this one. It is important that the information be as accurate as possible. Please provide the following information from the financial statements of this firm.*

31. For the fiscal year 2006, please provide the following information about your firm

	Ksh
a. Total annual cost of raw materials and intermediate goods used in production	
b. Total annual costs of electricity	
c. Total annual costs of fuel	

32. In the fiscal year 2006, what is the total annual expenditure for purchases of:

	Ksh
a. Machinery, vehicles and equipment (new and/or used)	
b. Land and buildings	

33. What is the net book value, the value of assets after depreciation, of the following at the end of fiscal year 2006?

	Ksh
a. Machinery vehicles, and equipment	
b. Land and buildings	

34. In fiscal year 2006 if this establishment had to hypothetically purchase the land and buildings, and machinery and equipment in use now, as they are in their current condition, how much would it cost to purchase each of the following?

	KSH
a. Machinery vehicles, and equipment	
b. Land and buildings	

35. In the fiscal year 2006 what is the total annual sales for this firm Ksh_____

APPENDIX C

Classification of technology-based firm

Table1: OECD Industry classifications based on global technology intensity.

Industry	ISIC Rev.3
High technology industries	
Aircraft and spacecraft	353
Pharmaceuticals	2423
Office accounting and computing machinery	30
Radio, TV and communication equipment	32
Medical precision and optical instruments	33
Electrical machinery and apparatus	31
Motor vehicle, trailers and semi-trailers	34
Railroad equipment and transport equipment n.e.c	352+359
Medium –high technology industries	
Chemicals excluding pharmaceuticals	24 excl.2424
Building and repairing of ships and boats	351
Rubber and plastic products	25
Coke, refined petroleum and products and nuclear fuel	23
Other nonmetallic mineral products	26
Basic metal and fabricated metal parts	27-28
Low technology industries	
Manufacturing n.e.c; recycling	36-37
Wood, pulp, paper products, printing and publishing	20-22
Food products, beverages and tobacco	15-16
Textile products, leather and footwear	17-19
Total manufacturing	**15-37**

Source: OECD, (1997).

APPENDIX C CONTN..

Table 2: Technological classification of manufacturing products

Manufactured products	*Example of product*
Resource-based manufactures	
Agro/forest based products	Prepared meats/fruits, beverages, wood products, vegetable oils
Other resource based products	Ore concentrates, petroleum/rubber products, cement, cut gems, glass
Low technology manufactures	
Textile/fashion cluster	Textile fabrics, clothing, headgear, footwear, leather manufactures, travel goods
Other low technology	Pottery, simple metal parts/structures, furniture, jewellery, toys, plastic products
Medium technology manufactures	
Automotive products	Passenger vehicles and parts, commercial vehicles, motorcycles and parts
Medium technology process industries	Synthetic fibres, chemicals and paints, fertilizers, plastics, iron, pipes/tubes
Medium technology engineering industries	Engines, motors, industrial machinery, pumps, switchgear, ships, watches
High technology manufactures	
Electronics and electrical parts	Office/data processing/telecommunications equip, TVs, transistors, turbines, power generating equipment
Other high technology	Pharmaceuticals, aerospace, optical/measuring instruments, cameras

Source: Sanjay lall, (2000)

APPENDIX D:

T-test difference of means for innovators by firm size and trade integration

	Mean	*Mean difference*	*P-value*	*T-statistic*
Exporter	0.545			
Non-exporter	0.271	0.282***	0.003	3.156
Foreign	0.520			
Domestic	0.506	0.403**	0.027	2.283
Small	0.377			
Large	0.546	0.185*	0.07	1.893

Source: Author

APPENDIX E

Muilticollinearity diagnostics

Dependent variable: Log value-added per worker (LOGVA/L)	Collinearity Statistics	
	Tolerance	VIF
LOGVADD	0.728	1.373
CAPITAL	0.482	2.073
CAP_UTILZ	0.812	1.231
AGE	0.838	1.194
EXPORTER	0.670	1.492
FOREGN	0.626	1.597
SIZE	0.506	1.975
RDD	0.812	1.232
RDDRATIO	0.713	1.402
COMPUT	0.576	1.736
WEBUSE	0.515	1.942
INNOVAT	0.575	1.740
TECHAQUI	0.459	2.180
DEGREE	0.798	1.254
PROFSHA	0.671	1.490
TRAINING	0.715	1.398
CREDIT	0.685	1.460
COMP	0.857	1.167
UNIVERSIT	0.569	1.757
CUSTOMER	0.550	1.819
SUPPLIER	0.641	1.559

Source: Author