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China's Presence in Developing Countries' Technology Basket: The Case of Furniture Manufacturing in Kenya

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China's Presence in Developing Countries' Technology Basket: The Case of Furniture Manufacturing in Kenya

Thesis submitted for the degree of Doctor of Philosophy
(Development Economics)

Development Policy and Practice
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The Open University

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DEDICATION

To my mother, Charlotte

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"The world is very different now. For man holds in his mortal hands the power to abolish all forms of human poverty and all forms of human life".

(Inaugural Address of John F. Kennedy, White House, Washington, USA, Friday, January 20, 1961)

ABSTRACT

China has emerged as the leading source of capital goods for Kenya and Sub Saharan Africa as a whole, which before the noughties depended largely on advanced countries for capital goods. Thus, there is a disruption of the pattern of technology transfer to Sub Saharan Africa including Kenya. A significant aspect of this disruption is that the capital goods are being produced within a developing country context (China) and for other developing countries. This issue motivated this research, which contributes to the literature by exploring the potential impact of Chinese technologies (capital goods) on the development of other developing countries vis-à-vis the impact of technologies from advanced countries and the domestic economy. The study used both qualitative and quantitative research approaches and data from Kenya's furniture manufacturing firms, including both formal and informal sector firms.

It was found that the technologies from China (and also Kenya) are more amenable for inclusive industrial development especially with respect to employment creation and poverty reduction. These technologies are more labour intensive, compared to the advanced country technologies. They allow poor entrepreneurs to start their own businesses with a relatively high degree of automation, which they would not be able to afford if the only available technology were the technology from advanced countries. They are also pro-poor in terms of producing goods to meet the consumption needs of the poor. It was also found that the diffusion of the Chinese technology is higher among informal sector firms than among formal sector firms. However, the Chinese technology is less common than the Kenyan technology in the informal sector while the formal sector firms mainly rely on the advanced country technology. All the three technologies are transferred/ diffused mainly through arm's length trade.

The fact that the Chinese and Kenyan technologies yield a more inclusive development outcome than those from advanced countries indicates that industrial policies for developing countries should take into consideration the critical issue of technology choice.

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LIST OF ACRONYMS

AD	Asian Drivers
AERC	African Economic Research Consortium
AIC	Akaike Information Criterion
AICD	Africa Infrastructure Country Diagnostic
AT	Appropriate Technology
BCR	Benefit Cost Ratio
BIC	Bayesian Information Criterion
BOP	Balance of Payment
BRICs	Brazil, Russia, India and China
CBS	Central Bureau of Statistics
CNC	Computerised and Numerically Controlled
DR	Democratic Republic
EU	European Union
FDI	Foreign Direct Investment
FOCAC	Forum on China Africa Cooperation
GDP	Gross Domestic Product
GVC	Global Value Chain
ICT	Information, Communication and Technology
ILO	International Labour Organisation
IMF	International Monetary Fund
IS	Import Substitution
K/L	Capital labour ratio
KAM	Kenya Association of Manufacturers
KMO	Kaiser-Meyer Olkin
LICs	Low Income Countries
MATRADE	Malaysian External Trade Development Corporation

MDGs	Millennium Development Goals
MICs	Middle Income Countries
MSEs	Micro and Small Scale Enterprises
NPV	Net Present Value
O/K	Output capital ratio
O/L	Output labour ratio
ODA	Official Development Assistance
OECD	Organisation for Economic Cooperation and Development
PCA	Principal Component Analysis
PhD	Doctor of Philosophy
PPP	Purchasing Power Parity
R&D	Research and Development
ROSCA	Rotating Savings and Credit Associations
SAPs	Structural Adjustment Programmes
SSA	Sub Saharan Africa
STI	Science, Technology and Innovation
TIVET	Technical, Industrial, Vocational and Entrepreneurship Training
UK	United Kingdom
UN	United Nations
UNIDO	United Nations Industrial Development Organisation
US	United States
USA	United States of America
USAID	United States Agency for International Development
USD	United States Dollars
WDI	World Development Indicators
WW II	World War II
WWF	World Wide Fund

CHAPTER 1 : RESEARCH MOTIVATION

1.0 Introduction

Economic growth in Sub Saharan Africa (SSA) has more than doubled between the early 1990s and the end of the first decade of this millennium, with the growth rate averaging 5% per annum between 2001 and 2010 (World Bank, 2011). Nevertheless, a large part of the same period witnessed "an increase in the incidence and absolute number of people living in income poverty", with almost half of the region's population still living on less than US$1 dollar a day (Handley *et al.*, 2009 p 1). This has however occurred at a time, when global absolute poverty level has declined (Chen and Ravallion, 2013). Careful analysis of the global poverty profile rather shows that aside from China, the rest of the world experienced an increase in absolute poverty cases during the noughties compared to the 1990s (Kaplinsky, 2011a, Chataway *et al.*, 2013). Kaplinsky (2011a) shows that although the global number of people living in absolute poverty fell by 339 million between 1998/1999 and 2007/2008, China alone accounted for 516 million out of the 339 million, suggesting that 177 million people were actually pushed below the poverty line when China is not included in the computations. SSA is a major contributor to the increases as the number of people living in absolute poverty in SSA soared by 59% between 1990 and 2008 (Chataway *et al.*, 2013).

The poverty situation in Kenya reflects these developments: Estimates based on available data show that the number of people living in absolute poverty increased by 9.6 million[1] people between 1997 and 2005. Relative poverty has also increased as a result of worsening inequality (World Bank, 2013). While it will be difficult to fully attribute this development impasse to the trajectory of policy and development related to technology choice, industrialisation and agricultural mechanisation efforts since independence have largely relied on imported technologies especially those from advanced countries (Meilink, 1982; Ikiara, 1984; Mutai, 2011). Such efforts may have not contributed to inclusive growth and

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[1] The figure was estimated by the author using data from World Development Indicators (World Bank, 2013)

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development in Kenya. As pointed out by an International Labour Organisation's (ILO) report on Kenya in the early 1970s, the high industrial growth in Kenya in the 1960s largely served the interest of a few people in the formal sectors of the economy, much to the disadvantage of the majority in the informal sectors (ILO, 1972). This outcome is associated with the fact that industrial policies in the 1960s and 1970s supported import substitution industrialisation, which inadvertently promoted the use of imported technology (Ikiara *et al.,* 2004; Coughlin and Ikiara; 1988).

At the global level, it is argued that the trajectory of innovation and technical change is a major factor which has allowed the high and increasing absolute poverty levels to prevail in an era of improved economic growth (Kaplinsky, 2011a). This argument questions the appropriateness of technologies emanating from high-income economies for promoting pro-poor economic growth in developing countries. It is argued that these technologies target high-income consumers, are highly capital and skill intensive and are for realising scale economies, with much reliance on sophisticated infrastructure (Kaplinsky *et al*., 2009). Meanwhile, income levels are generally low in developing countries, labour particularly unskilled is more abundant, and infrastructure is much less developed, compared to the advanced countries from where the technologies originate.

Thus, when technologies from advanced countries are transferred "wholesale" to developing countries, as it has occurred over the years (for example, under Kenya's import substitution industrialisation), several structural problems are created in the recipient economies (Stewart, 1982). The characteristics of the technologies reduce the much needed employment creation, lead to a limited use of local inputs and sub-optimal growth outcomes, and make inefficient use of local factors (Bhalla, 1985; Stewart, 1982). It is further argued that such technologies also skew production to meeting the needs of high-income consumers who form an insignificant proportion of a developing country's population. Moreover, the industries using such technologies cluster in enclaves in urban areas, as they tend to have limited linkages with traditional sectors and in their developed stages of operations they undermine informal and/ or traditional sectors (Kabecha, 1999). Consequently, it is perhaps

no surprise that industrialisation efforts in most developing economies have not yielded much success, either in terms of output growth (limited share in global manufacturing value added) or in terms of fostering inclusive growth and development.

Within the last three decades, however, China (a developing country) has experienced a phenomenal rise in economic power, contributing significantly to global manufacturing value added and trade in manufactures including capital goods. This new trend may be associated with China's substantial and growing contribution to developing countries' increasing share in global research and development (R&D) activities. Developing countries' share in global R&D expenditure was estimated at 21% at the beginning of the 21st century compared to 2% in late 1960s (Ely and Bell, 2009). A significant share of this expenditure occurred in China, where R&D increased 21% annually in the last decade (Atkinson, 2012), with manufacturing's share in business R&D being 87% in 2008 (McKinsey, 2012). Current estimates of R&D expenditure indicate that China is the third largest R&D performer after United States and Japan (Kim, 2014).

The high growth in R&D activities in China and its associated increases in China's share in global manufacturing value added have been accompanied by innovative capability building in China (OECD, 2007; Atkinson and Ezell, 2012; Orr and Roth; 2012) and significant reductions in poverty numbers in China as was pointed out earlier. Casual empiricism asserts that at the heart of the innovation path in China is the development of technologies that appear to be suitable for the operating conditions in China as well as other developing countries*:*

> Spurred by demand from low income consumers, low labour prices and often poor infrastructure, China is becoming a source of appropriate technology, that is, appropriate for the operating conditions of low income economies. But unlike previous vintages of appropriate technology which were diffused by NGOs and were often inefficient, this new generation of appropriate technologies coming out of China … is a result of profit-seeking capitalist entrepreneurship (Kaplinsky, 2011a p. 7).

Interestingly, this is occurring at a time when there is a better understanding of the innovation system and the role of technical change in economic growth and development. Against the orthodox belief that technology is like *manna from heaven,* technical change/ innovation is

now understood to be endogenous to the economic/production system (Heertje, 1977; Gibbons *et. al.*, 1994; Greenwood and Jovanovic, 2001). Underpinning the new paradigm is the theory of induced technical change, which holds that the nature of demand, factor endowments, and other economic factors can influence the direction of technical change (Binswanger, 1978; Kline and Rosenberg, 1986; Thirtle and Ruttan, 1987). Thus, different socioeconomic settings can lead to different patterns of technical change such that technologies produced in a developing country, for example China, may possess characteristics that are different from those produced in advanced economies. Relatedly, it has been recognised that innovation does not only result from disinterested activities taking place in universities and research institutions (i.e. supply side), but the role that firms and consumers (i.e. demand side) play in the nature and direction of innovation as well as their interactions with the supply side are also important (Kline and Rosenberg, 1986; Pavitt, 1984; von Hippel, 2005).

The issues discussed in the preceding paragraphs provided the main motivation behind this research. The thesis studies technological innovations from China in the context of other developing countries by making comparisons with technologies from other sources particularly advanced countries. The objective is to move beyond assertion and casual empiricism to rigorously ascertain the extent to which the Chinese technologies are relatively more amenable for pro poor economic growth and development strategies for developing countries especially those in Sub Saharan Africa. Data collected from manufacturing firms in Kenya's furniture industry is used for the needed empirical analysis; hence, the focus of the study is limited to technologies (machinery and equipment) used for manufacturing furniture. The rationale behind selecting Kenya and the furniture sector for the empirical work is outlined later in Chapter 4.

The focus on manufacturing technology is born out of the fact that manufacturing in many developing countries has been a struggling sector, hardly delivering the expected returns or benefits such as opportunities for employment for their growing youth population (Dinh *et al.*, 2012). Moreover, most developing countries particularly those in Sub Saharan Africa depend

on imports even for basic manufactured goods. However, manufacturing is part and parcel of China's success story of lifting millions from poverty and doubling her per capita GDP in 12 years, a feat that took Great Britain 150 years to achieve (McKinsey, 2012). As Brautigam has indicated, "Manufacturing – more than microfinance – will be a central route out of poverty for most countries. That is why it is so important to discern whether engagement with China will catalyse or crush manufacturing in Africa" (2009 p 191). Undoubtedly, transfer of technologies from China to African countries and other developing countries may be one of the important ways by which China's engagement with Africa might impede or offer impetus to manufacturing on the continent.

1.1 Knowledge gap and research questions

China's relationship with Africa has grown enormously, especially in the last two decades with important implications for economic growth, distribution and policy (Kaplinsky *et al.*, 2007). An earlier documentation of China in SSA by Jenkins and Edwards (2006) also suggested that the impact of China and generally Asian Drivers[2] on SSA had not been and will not be negligible, calling for detailed research on individual countries in SSA.

In fact, recent data indicate a growing relationship between China and Africa. According to a White Paper from the Chinese Government, China-Africa trade as a percentage of Africa's total foreign trade increased from 3.82% in 2000 to 16.13% in 2012 (People's Republic of China, 2013). The same White Paper shows that there has been an accelerated growth in foreign direct investment (FDI) from China to Africa, with Chinese FDI increasing from US$1.44 billion to US$2.52 billion between 2009 and 2012, although there was a general decline in total FDI to Africa in the same period. Moreover, there has been a surge in Chinese development finance to Africa since the beginning of this century, with pledges of assistance doubling at each FOCAC summit: In 2006, US$ 5 billion was pledged and pledges for 2009 and 2012 were US$ 10 billion and US$ 20 billion respectively (Strange *et al.*, 2013). Associated with the upsurge in trade, FDI and development finance is the

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[2] This phrase is used in the literature to jointly describe China and India as emerging Asian economies with major implications for both the developing and developed world.

intensification of migration from China to Africa (Kuang, 2008; Mohan and Tan-Mullin, 2009; Park, 2009).

From trade to FDI and official development assistance (ODA) to migration, there are many myths surrounding the relationship between China and Africa, some of which are being dispelled. For example, research has shown that China's increasing interest in African economies is not solely driven by its quest for natural resources but much of it also lies in other factors such as the search for final markets, diplomatic support in international politics and its principle of mutual economic development partnership (Brautigam, 2009; Zweig, 2008; Dent, 2011). Specifically on FDI, Kaplinsky and Morris (2009) point out the distinctive character of large state-owned Chinese enterprises' investment in SSA and the opportunities it creates for bilateral and multilateral aid and economic cooperation between China and SSA. Research analysing the influence of China on trade and economic relations between African countries have also begun (e.g. Morris and Einhorn, 2008; Edwards and Jenkins, 2014). Morris and Einhorn (ibid) and other studies such as Khan *et al.* (2009) have also focused on the employment and welfare implications of cheap consumer goods from China. Moreover, studies on the motivations, relationships, and impact of Chinese migrants in Africa and the perceptions of their African hosts are emerging (e.g. Mohan *et al.*, 2014; Lampert and Mohan, 2014).

However, the academic community is still at an early stage in researching this evolving relationship and its impact on African economies. A significant gap remains in the literature. For example, while the impact of cheap Chinese consumer goods on SSA economies has been analysed, little is known in the literature about the effect of capital goods importation from China on SSA economies. Generally, a large gap exists in the literature on technology transfer from China to other developing countries, and in particular those in SSA, and the distinctiveness of such technologies especially with reference to their development impact. The literature on this subject appears sketchy, patchy and casual and has largely remained in the domain of media commentary. A lot of the focus has also been on specific investment projects. For example, in a web blog, Nordling (2012) provides a cursory discussion of the

technology transfer elements of investments in Africa by Chinese telecommunication companies such as Huawei and ZTE.

However, this gap in the literature exists in the presence of a plethora of studies on technology transfer, which has rather concentrated on technologies from advanced economies (such as The United Kingdom, Germany and Japan) that are transferred via direct investment activities of multinational firms. Examples of such studies include Mansfield (1975), Teece (1977), Contractor and Sagafi-Nejad (1981), Grosse (1996) and Chen (2005). As it will be shown in Chapter 3, a section of the literature has focused on the transfer process and the mechanisms of transfer while others have examined the appropriateness of these technologies for developing countries.

For technologies embodied in capital goods or machinery and equipment, the reason for this trend in the literature is obvious. Traditionally, China was not a major source of capital goods importation for SSA and other developing countries. This is because China's increasing role in the manufacturing and trade of equipment and machinery is a recent phenomenon, as can be seen in the information presented in Figure 1.1. The figure shows that China only recently emerged as a major source of capital goods importation, compared to countries such as the United States and Japan. Interestingly, China has become the largest source of SSA's imports of machinery and transport equipment since 2007, with substantial increases in importation occurring year after year particularly during the 2000s. The implication is that there is a general disruption of the pattern of technology transfer to developing countries. We now observe a situation where capital goods are being developed within a developing country (China) context and for developing countries, which hitherto depended extensively on capital goods from advanced countries.

Figure 1.1: SSA's major sources of machinery and transport equipment imports
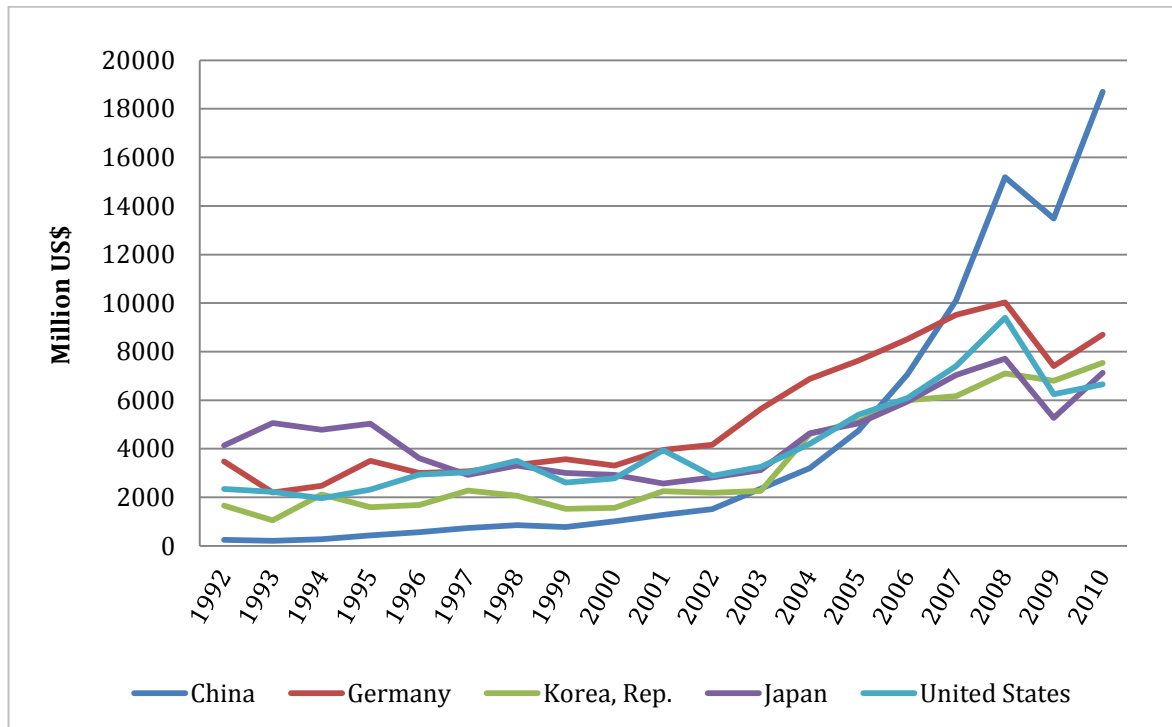
Source: UN COMTRADE accessed on 27 March 2012

Being a sub Saharan African country, Kenya is no exception to China's strengthening economic ties with developing countries. Chinese ODA to Kenya increased consistently from less than one percent (1%) of total ODA to Kenya in 2002 to about 8.25% in 2005, making China Kenya's second largest source of ODA after the European Union in 2005 (Onjala, 2008). In 2010, China emerged as the Kenya's leading source of FDI, with investment in that year totalling US $26.6 million (Juma, 2011; Patroba, 2012)[3]. Data from UN COMTRADE[4] shows that Kenya's trade with China has seen a significant rise from the year 2000, with Kenya recording an increasing trade deficit against China. China's exports to Kenya increased by more than tenfold in the last decade, with China emerging as the second largest source of imports for Kenya in 2010. The increase occurred in most of Kenya's major import items including machinery and transport equipment. Figure 1.2 depicts the dramatic increases in China's machinery export to Kenya in the last decade. The figure shows that

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[3] The Kenya Investment Authority is the primary source of the information provided in the secondary sources indicated.
[4] The data was accessed on 27 March 2012 via https://wits.worldbank.org/

China's exports saw steady increases in the 2000s, and as in the case of sub Saharan Africa, has emerged as the highest exporter of machinery to Kenya.

Figure 1.2: Kenya's major sources of machinery and transport equipment import
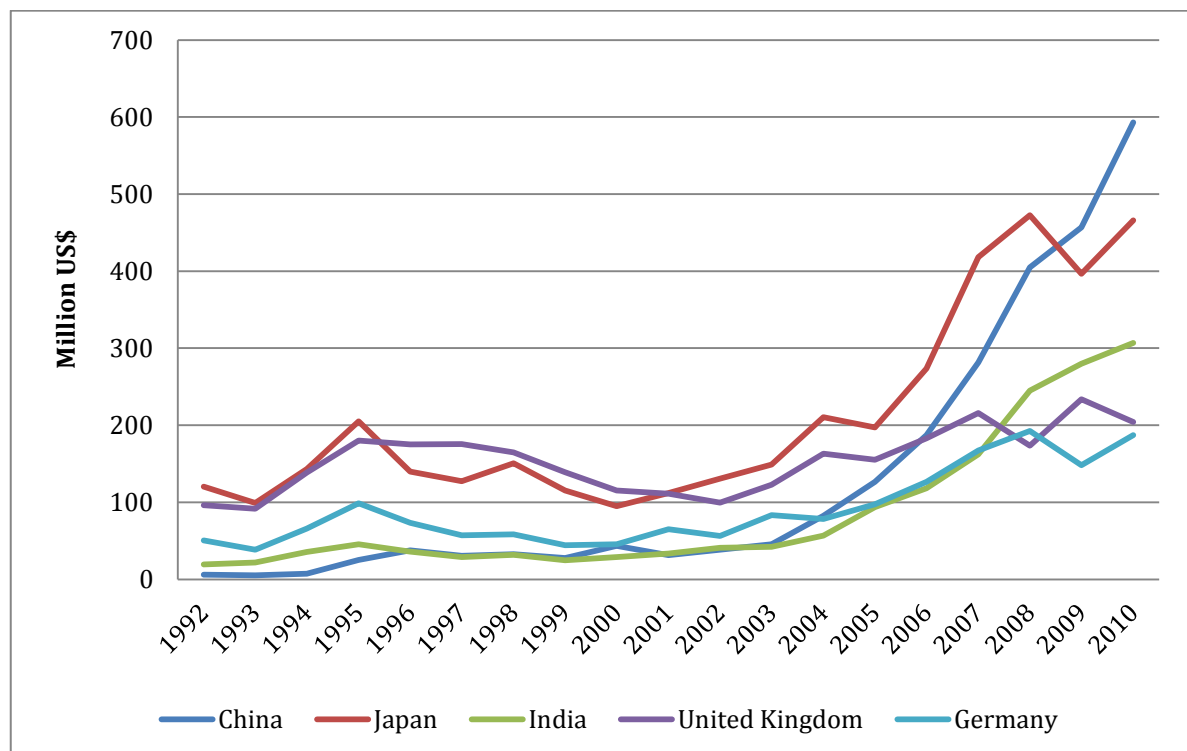
Source: UN COMTRADE accessed on 27 March 2012

The new trend in economic relations between Kenya and SSA on one hand and China on the other, particularly that observed in Figures 1.1 and 1.2 tells a compelling story about the changing mix of technology available to Kenya, and SSA more generally. It raises multiple questions especially in view of the fact that the empirical literature on the subject is patchy and anecdotal. In this regard, this thesis attempts to contribute to bridging the gap in the literature by finding answers to the following specific research questions:

- How distinctive are Chinese technologies used in Kenya's furniture making industry with respect to their technical and economic/social characteristics?
- How are the Chinese technologies transferred from China to the Kenyan firms compared to the advanced country technologies?
- To what extent have the firms adopted the Chinese technologies, compared to those from advanced countries and Kenya and what factors influence adoption?

The answers to the above research questions, generated through the empirical research on Kenya, will help determine the extent to which the Chinese technology may create more inclusive growth and development vis-à-vis the technologies from advanced countries.

1.2 Structure of the thesis

The thesis is divided into nine Chapters. Chapter 2 discusses Kenya's development trajectory and issues. The main points highlighted in the chapter converge around politics which has been largely "tribalised", economic performance and social developments as well as the level of attention given to technology choice in the industrial and development policies of the country.

Chapter 3 presents a review of the literature related to the subject areas of the thesis. Four main sets of literature are discussed: technology choice, appropriate technology, sources of technical change and technology transfer.

Chapter 4 presents a conceptual framework developed based on ideas from the literature reviewed in Chapter 3. The framework provides a guide to analysing the relationship between the concepts/variables studied in this thesis, of which the empirical data were collected from furniture manufacturing firms in Kenya. The chapter also discusses the data collection methods used and the various challenges in the data collection exercise.

Chapters 5 to 8 present the analyses of the empirical data. Chapter 5 presents information on the business and entrepreneurial profile of the firms studied. The main aim of the chapter is to provide an understanding about the nature and character of the firms. This helps to gain more understanding about the behavioural patterns of the firms particularly with regards to technology adoption/ choice and the transfer modes they use. Thus, this chapter does not directly answer any of the research questions. Its role in the thesis is to provide a background to the other three empirical chapters that directly answer the research questions.

Answers to the three research questions are presented chronologically in Chapters 6 to 8 to reflect the order of the research questions, as specified in Section 1.1. This is because,

chronologically, it makes sense to think of what/how the technologies are before thinking about how they get to the Kenyan furniture manufacturing firms. Similarly, it makes sense to think of how they get to the firms before thinking about the extent to which they have diffused in the furniture industry in Kenya. Chapter 6 therefore discusses the technical and economic characteristics of Chinese technology but in comparison with those from advanced countries and Kenya. As it will be noted later, the Chinese, advanced country and Kenyan technologies largely constitute the dominant technology types used in Kenya's furniture making industry. The discussion on the technical characteristics focuses on the functions of the machines, the run of the machines and their physical characteristics such as size and capacity. The discussion on the economic/social characteristics examines factors such as the purchasing and maintenance cost of the machines, skill and infrastructure requirements for investing in the technologies and the economic implications of some of the technical characteristics.

Chapter 7 examines the relative efficiency and factor intensities of the technologies. Also discussed are the returns on investment in the technologies, the modes of transfer and the financing options available for acquiring the technologies.

Chapter 8 presents findings on the level of penetration (or diffusion) of the technologies from China, advanced countries and Kenya in the furniture industry. The chapter also highlights several explanations for the observed patterns of penetration, based on evidence presented in Chapters 5 to 7 and additional information presented in Chapter 8. Also, the firms' and their operators' characteristics are examined as factors influencing adoption, thus penetration. Complementarities between the adoptions of the technologies are also examined.

Chapter 9 presents a summary of the previous chapters, outlining the major findings. It also examines what the findings suggest concerning an optimal technology choice for Kenya, based on the prevailing development imperatives of Kenya. The policy implications of the findings and the contribution of the study to the literature are also presented. The chapter ends the thesis with the author's reflections, culminating in several ideas for further research.

CHAPTER 2 : KENYA'S DEVELOPMENT TRAJECTORY AND ISSUES

2.0 Introduction

Kenya is an East-African country bordered by five other countries: Ethiopia and South Sudan to the North, Uganda to the west, with Somalia and Tanzania bordering the eastern and southern parts respectively. At the south-eastern ends lies the Indian Ocean giving Kenya some economic advantage over its landlocked neighbours such as Uganda and South Sudan. Like the neighbours and most other countries in Sub Saharan Africa, Kenya faces a number of socioeconomic, political and development challenges. The aim of this Chapter is to present an overview of the prevailing development situation in Kenya, highlighting the trends over time and drawing attention to some of the correlates. This provides a context to the research motivation for this study and the analyses of the development and policy implications of the empirical work in this thesis.

The chapter first looks into politics and ethnicity issues in Kenya, followed by a discussion on economic development issues, which begins with discussions on economic growth performance and structural changes in sectorial compositions of aggregate economic activity, and then narrows down to the manufacturing and furniture sectors. Also discussed are the prominent role of the informal economy and its dynamism, and the patterns in Kenya's international trade relations. The chapter also discusses other issues such as inequality, the incidence of poverty, unemployment, education and infrastructural conditions in Kenya. Last but not the least, a few of the key industrial and development policy strategies or documents are reviewed to illustrate the limited level of emphasis that has been placed on technology choice as an issue for policy in Kenya.

2.1 Politics and ethnicity

Kenya became a British Crown colony in 1920 and gained independence in 1963. A significant feature of colonial Kenya was the dominant role of European settler farmers, who

with the support of the colonial government appropriated much of Kenya's arable land for agricultural plantation. The indigenes remained peasant farmers and a large proportion of the rural population had to work compulsorily on settler farms as wage labourers. To make cheap labour available on settler farms, a poll tax was introduced and Africans were also barred from commercial agriculture and this is believed to have had negative effect on African entrepreneurship (Leys, 1975). The impact of settler farming on Africans took several forms: unequal distribution of land; landlessness; economic and social discrimination; and economic repression (Leys, 1975; Sundet and Moen, 2009). While Europeans monopolised commercial agriculture, Asians particularly Indians, who came to Kenya mainly to provide labour for the construction of the Kenya-Uganda Railway, dominated real estate and trade sectors. The Indians were able to accumulate considerable wealth and entrepreneurial experience, which later enabled them to upgrade or diversify their businesses into varied areas of manufacturing (Leys, 1975). These factors largely contributed to the struggle for independence, which climaxed with the popular Kikuyu-dominated *Mau Mau* uprising, which began in 1952 and lasted for almost a decade (Leys, 1975).

However, little or no restructuring occurred in political administration after independence. The colonial political system practically continued with the following key characteristics: a centralised state with powerful executives, political conflicts based on issues of inequality particularly with reference to land, and the persistence of violent confrontation between the state and popular movements in the opposition (McSherry and Brass, 2007). According to Sundet and Moen (2009), instead of correcting anomalies in the political administration, Jomo Kenyatta (Kenya's first president) used patron-clientele network to woo opponents into his government so that as early as 1964 Kenya had become a *de facto* one party state. However, it was not until 1982 that Kenya became a *de jure* one party state, which remained until 1991. Daniel Arap Moi, who took over the presidency after Jomo Kenyatta's demise in 1978, sought to weaken decentralised institutions and other arms of government at the national level, with the executive appropriating more power and control (Sundet and Moen, 2009). The result was an inherently unstable political system, which manifested in several

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forms including the coup d'état attempt of 1982 (Sundet and Moen, 2009). However, unlike many other independent Africa countries, there was no successful coup d'état and Kenya enjoyed a relatively stable political environment under one party system.

With pressure from the international community, multi-party democracy was restored in 1992, but a change in the presidency only took place in 2002. The multi-party system became the litmus test for the apparent political stability in Kenya, which had thrived behind subdued tribal tensions arising from unequal distribution of land and unequal access to public goods and services. Mwai Kibaki became the president from 2002 to 2007, at the end of which another election was held. The run up to this election was noticeably violence free, much like what happened in 2002. However, flawed electoral processes led to a post-election violence, in which thousands lost their lives. A power-sharing deal between the incumbent president (Mwai Kibaki) and the major opposition leader (Raila Odinga) helped to restore peace.

The major catalyst for the post-election violence was tribal sentiments linked to social injustices, regional inequality, high unemployment and unequal access to land. Gutiérrez-Romero (2010) specifically points out that land disputes arising from unequal redistribution of land that was reclaimed from the settler farmers has been a key reason for tribal sentiment in Kenya, which politicians have preyed on to achieve their short term goals. Consequently, politics in Kenya has become ethno-centric to the extent that even church leaders openly campaign and support camps of their ethnic groups (Gumo *et al.*, 2012). Several other studies such as Kimenyi (1997), Apollos (2001), Orvis (2001) and Bratton and Kimenyi (2008) show that ethnicity plays a central role in Kenya's politics influencing patterns of political mobilisation and voting, resource allocation and public service appointments. Gutiérrez-Romero's (2010) study further shows that ethnicity was the main determinant of voting in the 2007 elections in Kenya and the reason was that people believed voting for their tribal representatives would guarantee an improved access to public services.

Kenyans went to the electoral polls again in 2013, which according to international observers were free and fair. Uhuru Kenyatta (a first generation progeny of Jomo Kenyatta) emerged as

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the president. Although, the main opponent (Raila Odinga) contested the results, the dispute was calmly settled through the judicial system, which appears strengthened with the promulgation of a new constitution in 2010 which replaced that of 1969.

2.2 Economic development

2.2.1 Economic growth performance

Like the political institutions, the inherited economic structures from colonisation were largely preserved especially in the early years of independent Kenya (Leys, 1975; Holmquist et al, 1994). At the dawn of independence, the economy was highly controlled and regulated and based on a monopolistic private enterprise system and private property ownership, all of which formed a significant part of the colonial legacy (Leys, 1975; Legovini, 2002; Mwega and Ndung'u, 2004). According to Leys (ibid), if any significant change took place, it was 'Africanisation' of the economy, which ensured the transfer of the White Highlands to indigenes and the relatively gradual indigenisation of the civil service, some sectors of commerce and some positions in the corporate sector.

Nevertheless, the economy performed robustly until the mid-1970s. Real GDP recorded annual growth of 9.5% and 8.7% in 1962 and 1963 respectively, up from negative 7.7% in 1961 (Figure 2.1). This robustness continued through the first two decades of independent Kenya. Between 1963 and 1972, GDP grew at an annual average of 8.4%, translating into an average real per capita GDP growth of 4.8% per annum. The next decade saw the figures plummet although they were still relatively good: GDP and per capita GDP respectively recorded annual average growth rates of 4.8% and 0.9%. This development was reflected in the performance of all the major sectors of the economy: Agriculture; Industry (of which manufacturing has been the backbone); and Services sectors (Figure 2.2).

Figure 2.1: GDP and GDP per capita (annual growth), 1961-2012
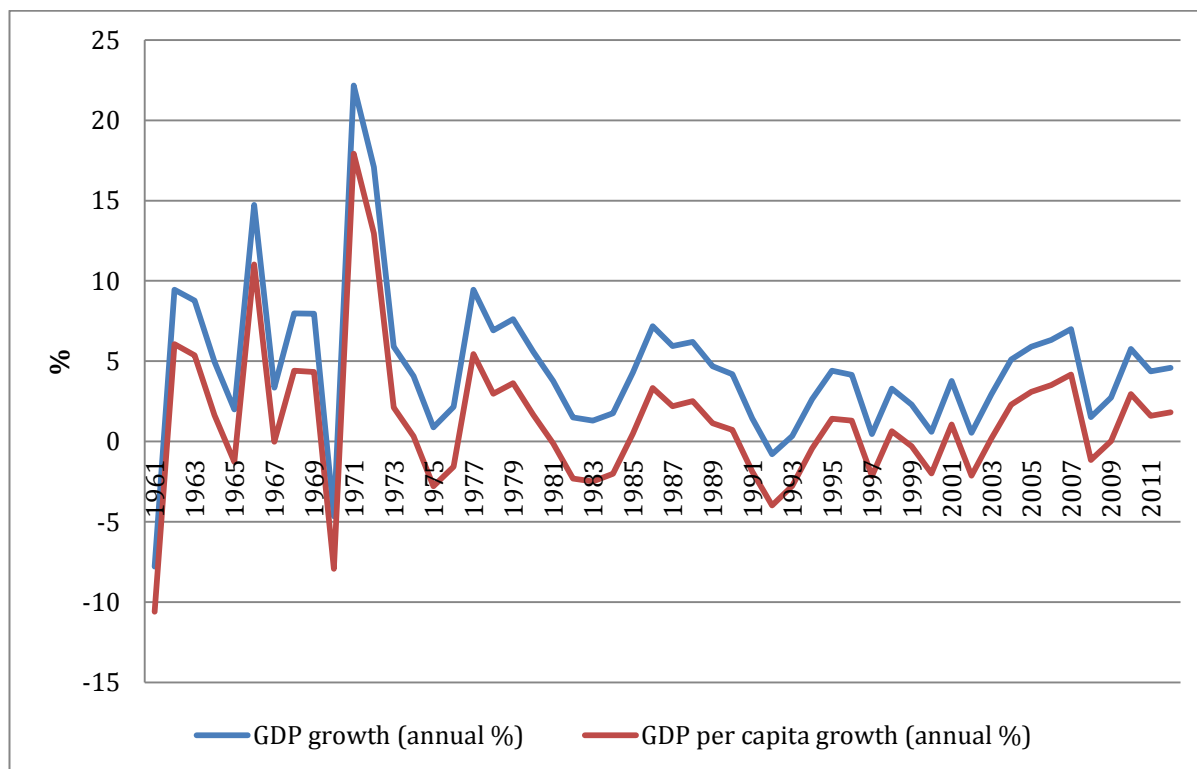
Source: World Development Indicators (World Bank, 2013)

Figure 2.2: Annual growth in value added for major sectors, 1965-2012
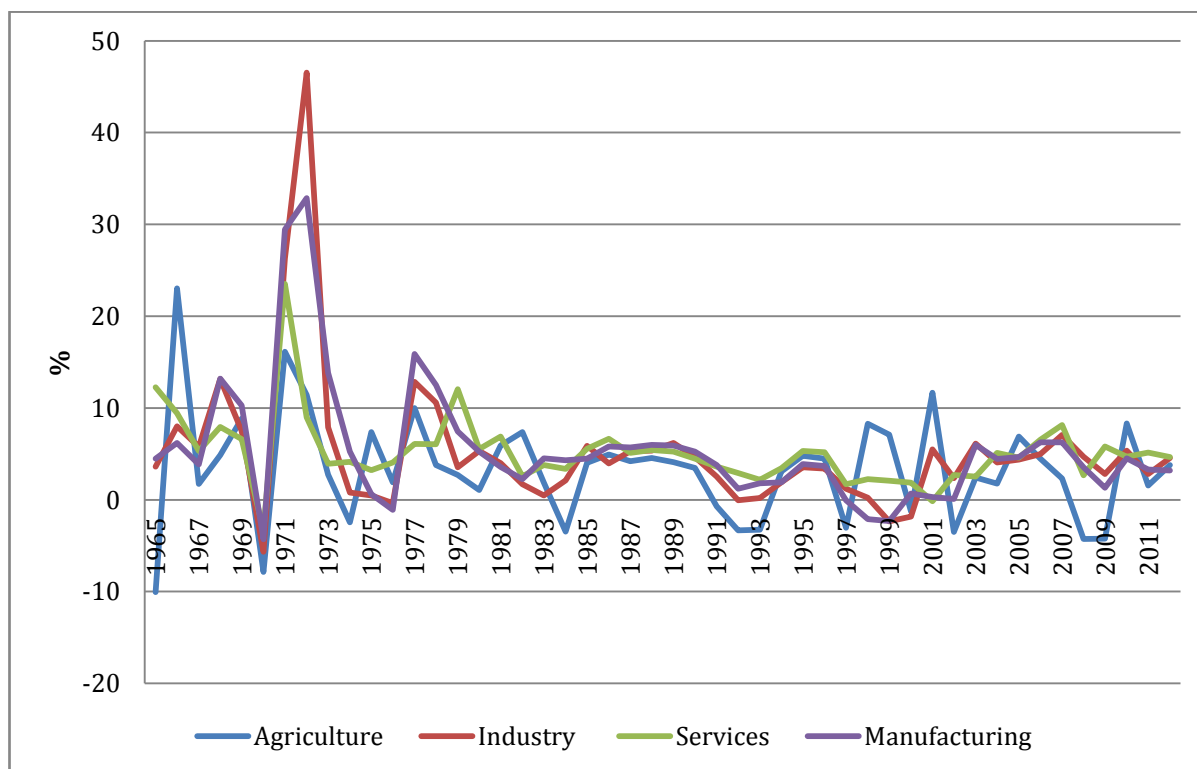
Source: World Development Indicators (World Bank, 2013)

Legovini (2002) cites several factors believed to be responsible for the relatively high performance of the economy in the first two decades after independence. First, many smallholder farmers benefitted from the redistribution of productive land and the government's programme to promote dairy farming and the cultivation of cash crops such as tea, coffee and hybrid maize. Consequently, it is argued that the smallholder farmers were more efficient than the large scale farming practiced by the European settlers (Leys, 1975). Second, the increased production in cash crops allowed for sustained growth in commodity exports between 1963 and 1980, which provided foreign exchange earnings to support the importation of capital goods, thus, encouraging investment. Third, import substitution (IS) industrial policy was implemented in this period and brought significant gains in the industrial sector's growth especially in the early years of implementation, with the manufacturing sub sector being the driving force. According to Ikiara (1984), the share of the manufacturing sector in GDP increased from 9% in 1963 to 13.5% in 1983.

The economy's momentum started to wear off from the mid-1970s. By early 1980s, the economy had plunged into a prolonged recession, lasting throughout the 1990s and into the early part of the 2000s. It should be noted that this period of sustained economic recession coincided with the political administration of Kenya's second president, Daniel Arap Moi, who ruled under an increasingly corrupt and a *de jure* one party-state system for a large part of the 24 years of his presidency.

Several economic factors have also been cited as contributing to the economic downturn. The first is associated with the IS policy. The policy did not largely move beyond the first phase[5] of implementation, while the system of control that came with it prevented product markets from developing to the extent that market prices were distorted (Mwega and Ndung'u, 2004; Ronge and Nyangito, 2000). Furthermore, ILO (1972) indicates that the IS policy had serious weaknesses in relation to employment creation, which was crucial in the face of the rapidly growing Kenyan population. The explanation for this is that the IS policy

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[5] Ogonda (1992) describes three phases of IS industrialisation. The first phase involves the local production of mass consumption goods. The second phase sets in motion local production of intermediate goods while at the third phase capital goods industries are developed.

relied heavily on capital intensive/ labour saving technologies, which hindered employment creation and encouraged inefficient and rent seeking behaviour in the industrial sector (Meilink, 1982; Legovini, 2002). Ikiara (1984) also indicates that the manufacturing sector became largely dependent on foreign inputs, with production being highly skewed towards consumer goods, which further discouraged the production of intermediate and capital goods. It also led to the creation of excess capacity and low technical efficiency, and negatively affected the ability of firms to penetrate foreign markets (Bigsten, 2001).

The second factor is related to the poor policy response to a series of oil price shocks in the 1970s and 1980s, which culminated in balance of payment (BOP) crises and inflationary pressures. According to Mwega and Ndung'u, "…the easy reaction to the crises in the early 1970s prevented the policy makers from formulating and adopting stabilisation and adjustments measures and policies … that could re-orient the economy in the phase of internal and external shocks" (2004 p 14).

Third, government's role in the economy expanded: Government expenditure skyrocketed in 1970s and 1980s, leading to fiscal imbalances and putting extreme pressure on domestic credit and inflation (Legovini, 2002). As Figure 2.3 shows, inflation moved swiftly from very low rate (near-zero range) in the 1960s to double digits in the 1970s. Inflation in the years after the 1960s has generally remained high, becoming an attendant feature of Kenya's economy and largely pulling along lending rates and raising the real cost of borrowing (Figure 2.3). Figure 2.3 shows that real interest rate still remains high with an estimate of 12% and 9% in 2010 and 2012 respectively.

In order to reverse the imbalances in the economy, policy reforms started in the 1980s, and followed the World Bank-International Monetary Fund (IMF) Structural Adjustment Programmes (SAPs). SAPs required product and financial markets liberalisation, international trade liberalisation, government budget rationalisation, divestiture and privatisation of parastatal industries and civil service reforms. However, the implementation of structural reforms embodied in SAPs did not achieve the expected results. Mwega and

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Ndung'u note that "… controversy surrounding these policies has tended to mask the broad goals and benefits, mostly due to the conditionalities that were attached. In the end, … they did not achieve their intended goals" (2004 p 24).

Figure 2.3: CPI inflation, lending rates and real interest rates
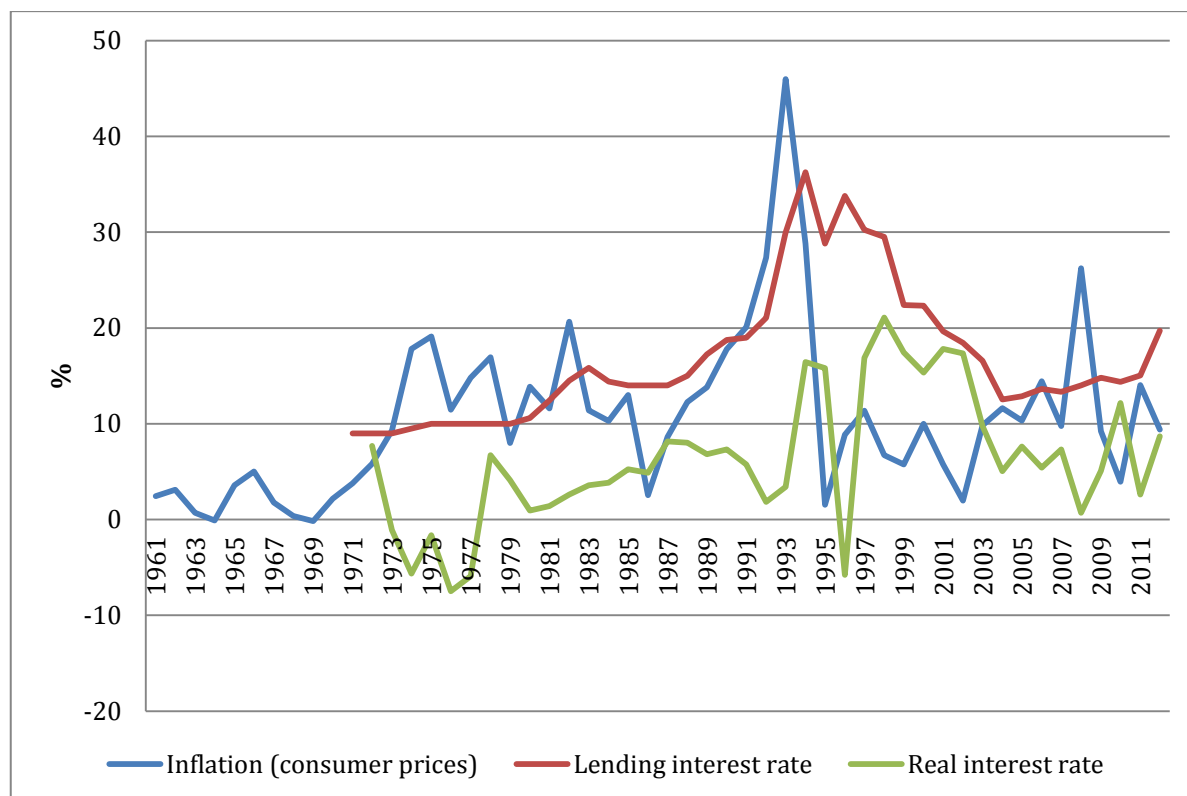
Source: World Development Indicators (World Bank, 2013)

Alongside the structural reforms, the country's industrialisation policy gradually changed from import substitution to export-led approach, a transition that was backed by policies enshrined in policy documents such as *Session Paper No. 1 of 1986* and *Sessional Paper No. 2 of 1996*. However, the success of this policy shift has also been limited (Takahashi *et al.*, 2007; Marti and Ssenkubuge, 2009). Marti and Ssenkubuge (ibid.) specifically note that the transition has led to the development of a large number of micro- and small-scale industries, but these industries are mainly informal and tend to have limited linkages with larger exporting industries.

The above policy interventions yielded little or no benefits; hence, the poor economic performance continued through the 1990s and the early part of the 2000s. Figure 2.1 shows

that real GDP growth remained relatively low in this period and value added in all the major sectors of the economy were also relatively low (Figure 2.2).

The economy began recovering from the protracted recession in 2003. By and large, the recovery has continued up to today, a period that largely coincides with Mwai Kibaki's presidency. However, it is important to note that the global food and financial crisis of 2008 together with the post-election violence and a drought in 2008 nearly truncated the recovery process. Real GDP grew at 1.6% in 2008, down from 7% in 2007, the pre-crisis year. The recovery has however resumed as conditions have started to normalise: Real GDP growth stood at 5.3% and 4.6% in 2010 and 2012 respectively.

Table 2.1: Real GDP growth (annual %) and real per capita GDP (PPP, constant 2011 international $)

Country	Variable	1980-1989	1990-1999	2000-2009	2000-2012
Kenya					
	GDP growth	4.2	2.2	3.6	4.9
	GDP per capita		1846.7	1863.5	2073.1
Uganda					
	GDP growth	3.0	6.9	7.2	5.3
	GDP per capita		753.3	1048.9	1320.7
Tanzania					
	GDP growth		3.3	6.8	6.8
	GDP per capita		988.4	1257.5	1598.5
Low income					
	GDP growth	2.7	2.5	5.1	6.2
	GDP per capita		1034.6	1231.4	1527.0
Sub-Saharan Africa					
	GDP growth	1.7	1.9	5.1	4.5
	GDP per capita		2241.9	2598.5	3101.4
World					
	GDP growth	3.1	2.7	2.6	3.1
	GDP per capita		9046.9	11266.2	13227.0

Source: World Development Indicators (World Bank, 2013)

Generally, as a result of the chequered economic performance since the mid-1970s, growth in per capita real GDP (PPP, measured in constant 2011 international dollars) has been low. Between 1990s and 2000s, for example, real per capita GDP increased by only 1% from an

average of $1,846.70 in 1990s to $1,863.50 in the noughties (Table 2.1). This indicates both the extent to which the economy has stagnated in terms of economic growth and the extent to which high population growth may have robbed gains from increases in real GDP. Kenya therefore remains a low-income economy, with real GDP per capita being substantially lower than the average for Sub Saharan Africa although it is slightly better than neighbouring Tanzania and Uganda. However, economic growth in Tanzania and Uganda during the last decade has generally been better than in Kenya (Table 2.1).

2.2.2 Major Sectors and structural changes

The Kenyan economy at the onset of political independence had a relatively balanced structure in terms of the major economic sectors' (Agriculture, Industry and Services) contributions to GDP. The agriculture sector's contribution to GDP was about 40%, compared to 43% for the services sector and 16% for industry. Figure 2.4 shows that the contribution of the agriculture sector has dwindled, trending downwards from the time of independence up to today. With the contribution of industrial sector generally remaining the same over the years as a result of unsuccessful efforts at accelerating the pace of industrialisation, the decline in the agriculture sector has resulted in significant gains for the services sector. In 2012, the agriculture sector's share of GDP was estimated at 25%, compared to 19% and 56% respectively for the industry and services.

The agriculture sector is however the main source of export earnings for Kenya and for raw materials used in agro processing in Kenya. It also remains the major source of livelihood for most Kenyans especially the rural population despite the fact that only 15% of Kenya's total land area (569,250 square kilometres) is considered arable. Estimate for 2007 indicates that this sector employs 75% of the labour force, with industry and services constituting only 25% (Central Intelligence Agency, 2012). This seems to suggest that the phenomenal expansion in the services sector has not resulted in creating more employment and may have negatively affected income distribution.

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Figure 2.4: Value added for major sectors as a percentage (%) of GDP, 1960-2012
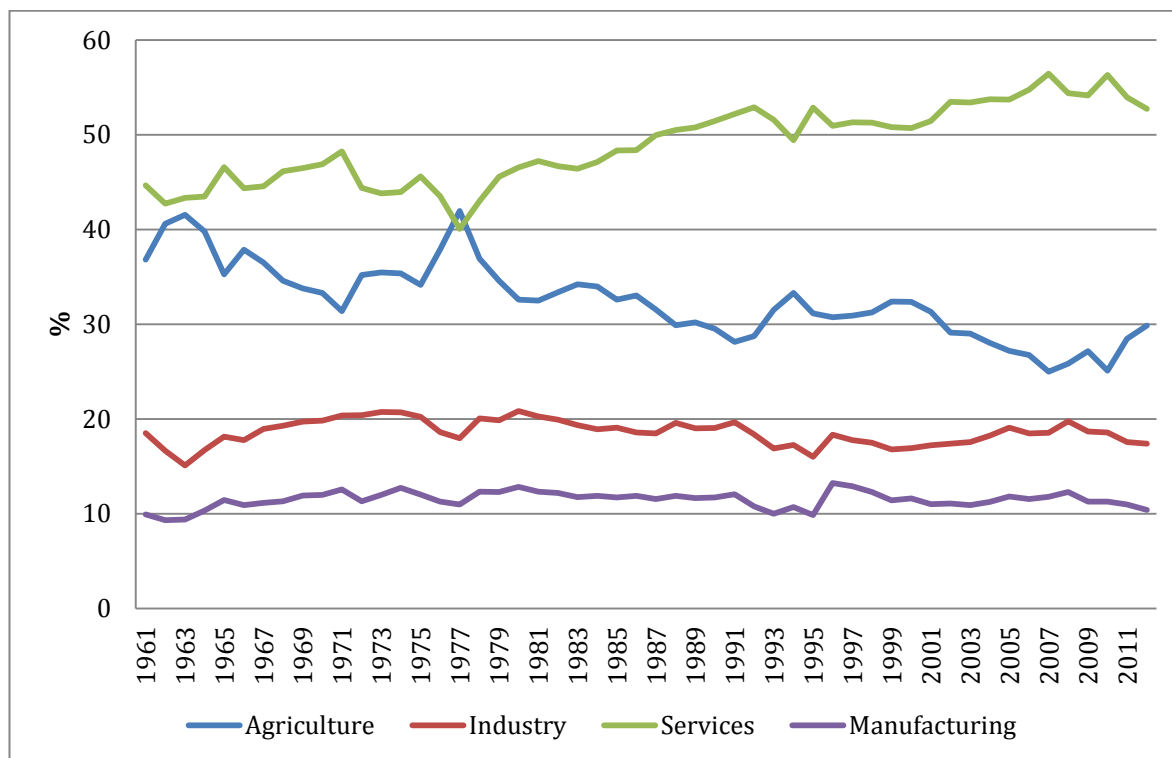
Source: World Development indicators, World Bank (2013)

2.2.3 The manufacturing sector

Figure 2.4 shows that developments in the manufacturing subsector drives developments in the industrial sector; the trend for industry's contribution to GDP mirrors that for the manufacturing subsector. Throughout Kenya's economic history, manufacturing has accounted for over half the size of the industrial sector. In 2010, for example, the subsector accounted for about 11 percentage points of the industry's 19% share in GDP.

Table 2.2 presents data on the contributions to value added and employment by the subsectors within the manufacturing sector in Kenya. The table shows that in terms of contribution to value added, four of the 14 subsectors dominate manufacturing, contributing a total of over 55% of value addition in each of the years provided in the table. Food processing remains the largest contributor with 19% share in 2008, followed by petroleum refinery, oil and vaseline (15%), non-metallic mineral products (13%), and tobacco and beverages (9%) in that order. Textile and clothing, and wood and furniture subsectors are

typical examples of the subsectors with relatively insignificant contributions to manufacturing value added in Kenya.

Table 2.2: Manufacturing subsectors' percentage share in value added and employment in the manufacturing sector

Subsector	2006		2008		2010	
	% share of value added	% share in employment	% share of value added	% share in employment	% share of value added	% share in employment
Total food manufacturing	20.37	30.68	19.34	30.62	21.81	30.62
Tobacco and beverages	9.04	3.44	9.19	3.26	10.06	3.26
Textiles and clothing	3.25	23.48	2.73	23.43	2.16	23.14
Leather and footwear	1.75	0.94	1.67	0.99	1.88	0.99
Wood and furniture	1.39	5.46	1.43	5.39	1.77	5.39
Paper and printing	6.51	6.66	6.4	6.6	4.75	6.6
Industrial chemicals, paint and soap	1.42	5.8	1.38	5.72	1.59	5.72
Petroleum refineries,oils, vaseline	15.38	0.09	15.32	0.09	10.62	0.09
Rubber products	1.34	1.26	1	1.41	1.05	1.41
Plastic products	1.93	3.15	1.39	3.27	1.52	3.27
Clay and glass products	1.46	2.58	1.76	2.75	2.04	2.73
Metal products	4.58	9.46	4.07	9.52	4.15	9.52
Non metallic mineral products	11.08	0.9	13.47	1.19	15.46	1.19
Transport equipment	1.76	3.57	1.53	3.09	2.02	3.09

Source: Chege *et al.* (2013)

However, the data on shares in the manufacturing sector's employment in Table 2.2 indicate that the textile and furniture subsectors create higher opportunities for employment than the subsectors that account for significantly higher proportion of output particularly the petroleum refinery sector. This sector contributes less than 0.1% to employment compared to about 5.4% for the wood and furniture sector and 23% for textile and clothing (Table 2.2). It should be noted that food processing dominates not only in terms of contribution to value added but also in terms of employment. However, a careful study of the numbers in the table shows that in relative terms the employment intensity of food processing is less than the textiles and furniture subsectors.

Another important feature of manufacturing in Kenya is the dominance of micro and small enterprises in the sector. Although the sector is made of firms of varied sizes, it is estimated

that informal micro and small-scale enterprises (MSEs) constitute about 85% of firms producing manufactured products in Kenya (Marti and Ssenkubuge, 2009). The products of MSEs meet the basic needs of the low and middle-income rural and urban people in Kenya who normally cannot afford products from formal manufacturing enterprises (Bigsten *et al.*, 2000).

The manufacturing firms especially the MSEs contend with many challenges, which negatively affect their growth. The challenges range from stiff competition from cheap imports and narrow export base to informality and the scourge of HIV/AIDS pandemic (Republic of Kenya, 2008a; Kenya Association of Manufacturers, 2006). Other challenges include limited access to financial services, high taxes, corruption and red tape, limited and costly physical infrastructure, and inadequate managerial, technical and entrepreneurial skills (Republic of Kenya, 1996; Soderbom, 2001; Bowen *et al.* 2009; Bigsten *et al.,* 2011).

The furniture subsector

Kenya's furniture industry has expanded significantly within the last decade. Data from United Nations Industrial Development Organisation (UNIDO) shows that in 2010 the value of total output of the furniture making industry in Kenya was US$ 172 million, compared to US$ 59 million a decade earlier[6]. This suggests that, in terms of output, the size of the sector has nearly tripled within a decade. Correspondingly, the UNIDO data further show that the sector achieved an average growth of 12% per annum between 2001 and 2010, making the furniture industry one of the fastest growing subsectors within Kenya's manufacturing sector.

Within the East African Sub Region, Kenya appears to have one of the most vibrant furniture manufacturing sectors. The data presented in Table 2.3 compares the production level of Kenya's furniture sector with those of other East African countries including Democratic Republic (DR) of Congo, for which data on furniture output were available from the UNIDO database. The data show that the furniture making industry in Kenya is much larger than those in the other countries. In fact, it is striking to find that Kenya's furniture production is far

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[6] The values for output and value added from UNIDO are in current prices

higher than DR Congo's production, given that DR Congo has a larger forest cover[7], and produces a lot of hard timber for exports to other countries. Currently, the furniture industry in Kenya depends greatly on hard wood (Mahogany) imported from DR Congo, an imperative that resulted from Kenya's Government's ban on indiscriminate logging in public forest in 1999. A report by World-Wide Fund on Eastern DR Congo's timber export to East Africa sub region, published in 2012, indicated that exports to Kenya constituted 55% of the total exports to East Africa.

Table 2.3: Value of furniture sector output in US Dollars (current prices)

Year	Kenya	Tanzania	Sudan	Eritrea	Madagascar	Congo DR
2000	59,000,000			6,337,242		6,253,020
2001	59,800,000		6,000,000	7,104,916	43,882,756	9,680,249
2002	60,400,000			8,525,455	38,903,973	10,262,730
2003	56,300,000	57,000,000		15,898,263	46,031,349	13,809,360
2004	56,200,000	37,600,000		15,269,048	33,870,916	17,507,595
2005	63,500,000	43,300,000		16,879,925	32,569,657	
2006	70,700,000	35,700,000		15,623,154	32,422,441	
2007	92,400,000	36,200,000		20,039,024		10,745,576
2008	116,000,000			16,809,496		12,235,236

Source: UNIDO online database, accessed on 11 October 2014

Like the manufacturing sector as a whole, Kenya's furniture making industry constitutes a major activity area for informal MSEs as well as formal manufacturing establishments, which together produce a wide range of furniture products. The informal MSEs largely produce cheap and poor quality products although some of them are able to manufacture high quality furniture, which attracts demand from formal sector of the economy (Bigsten *et al.*, 2000). These informal enterprises generally specialise in the production of domestic furniture while the firms operating in the formal sector produce both office and domestic furniture (MATRADE-Nairobi, 2005). According to Schneider (1999), local manufacturers have played

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[7] Source: World Bank online database, http://data.worldbank.org/indicator/AG.LND.FRST.ZS

a significant role in the furniture market in Kenya in that they have specialised in products that are usually difficult for foreign manufacturers to produce. For example, about 95% of furniture in the 1990s that hotels and lodges in Kenya (including the most luxurious ones) purchased came from local manufacturers (Schneider, 1999).

However, imported furniture appears to have gained a significant share of Kenya's furniture market in recent years. Figure 2.5 shows that between 1993 and 1997, value of Kenya's furniture export was consistently higher than the value of imports. However, from 1997 onwards, imports have outstripped exports with the gab widening year after year. Figure 2.6 indicates that a significant proportion of the surge in furniture importation into Kenya comes from China. While furniture importation from China was relatively low before the 2000s, the data presented in Figure 2.6 show phenomenal increases in China's furniture exports to Kenya, appropriating the market share of traditional sources such as the UK and South Africa (and perhaps, the domestic producers) in relative terms.

Figure 2.5: Value of Kenya's total imports and total exports of furniture
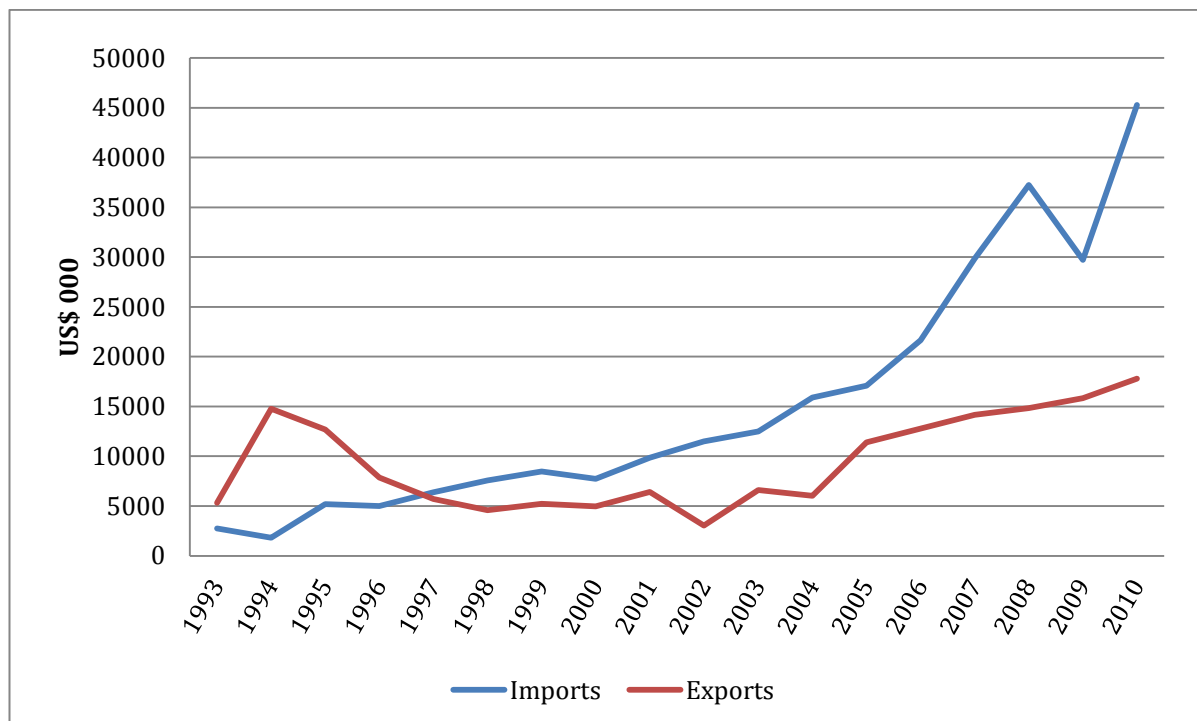
Source: UN COMTRADE, accessed on 3 October 2014

Figure 2.6: Kenya's furniture imports from major sources
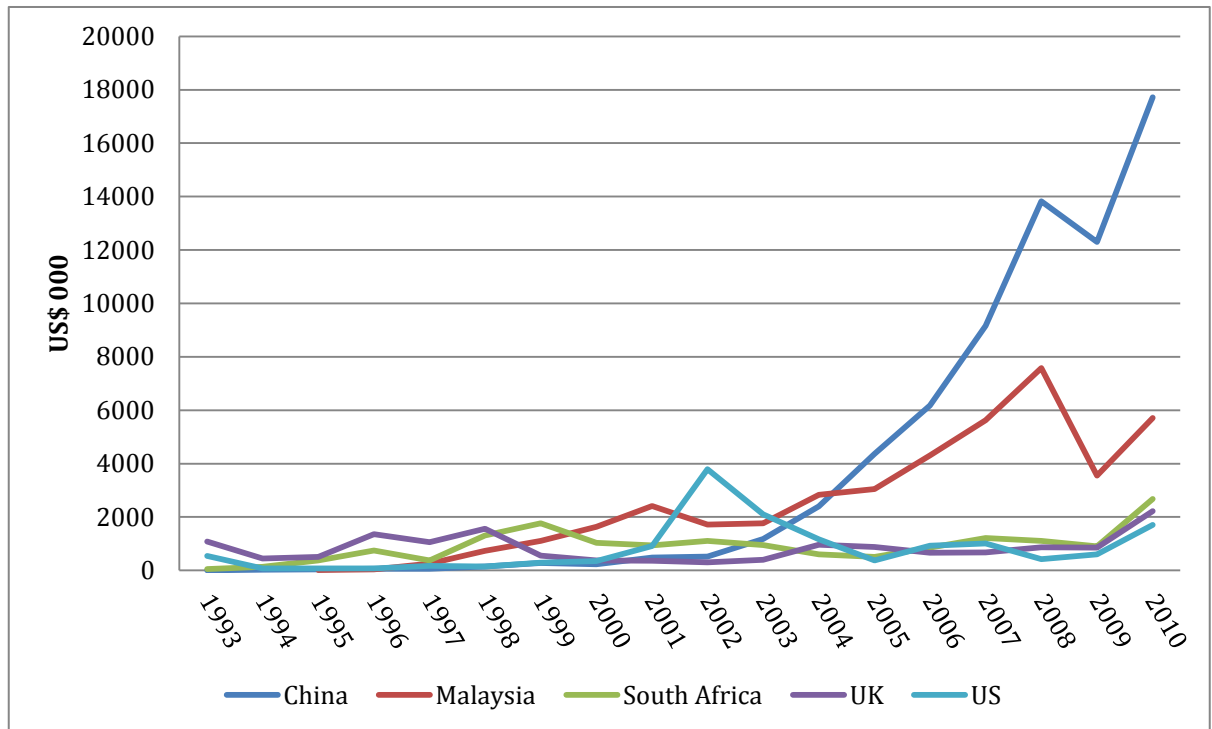
Source: UN COMTRADE, accessed on 3 October 2014

The trend shown in Figure 2.6 seem to offer some support to Namale's (2012) report that high importation of cheap furniture from China has recently displaced some of the local manufacturers (Namale, 2012). Namale (2012) reported that the advantage of the imported furniture from China over the made-in-Kenya furniture is that the furniture from China tend have better finishing. He however noted that consumers in Kenya have recognised that the imported furniture from China usually break often and are difficult to repair; hence, the consumers have started changing their preference back towards local products. This supports Schneider (1999) who found that the local manufacturers of furniture have significant advantage over imported products in Kenya's domestic market because they offer opportunity for maintenance, repairs and replacement.

The reversion of consumer preference towards locally made furniture reported by Namale (2012) appears to reflect in the growth of output and value addition in the furniture sector, which can be seen in the data presented in Figure 2.7. The figure shows that the sector has seen significant increases in production and value addition between 2005 and 2010, while

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both indicators stagnated between 1999 and 2005 after showing an upward trend from 1992 to 1998. However, the fact that imports from China is still growing (as indicated in Figure 2.6) may reflect the fact that generally consumer demand for furniture is expanding and import from China has only eaten into the potential growth of domestic production. Moreover, the impact of the ban on logging in 1999 may be the major factor which explains the trend in furniture production in Kenya rather than the massive influx of furniture from China. KOMAZA, a non-for-profit organisation, reported in 2011 that the ban led to timber scarcity and caused the closure of 300 saw mills. A significant part of the scarcity is now being made up for by imports from DR Congo, as was noted earlier.

Figure 2.7: Output and value added for Kenya's furniture sector
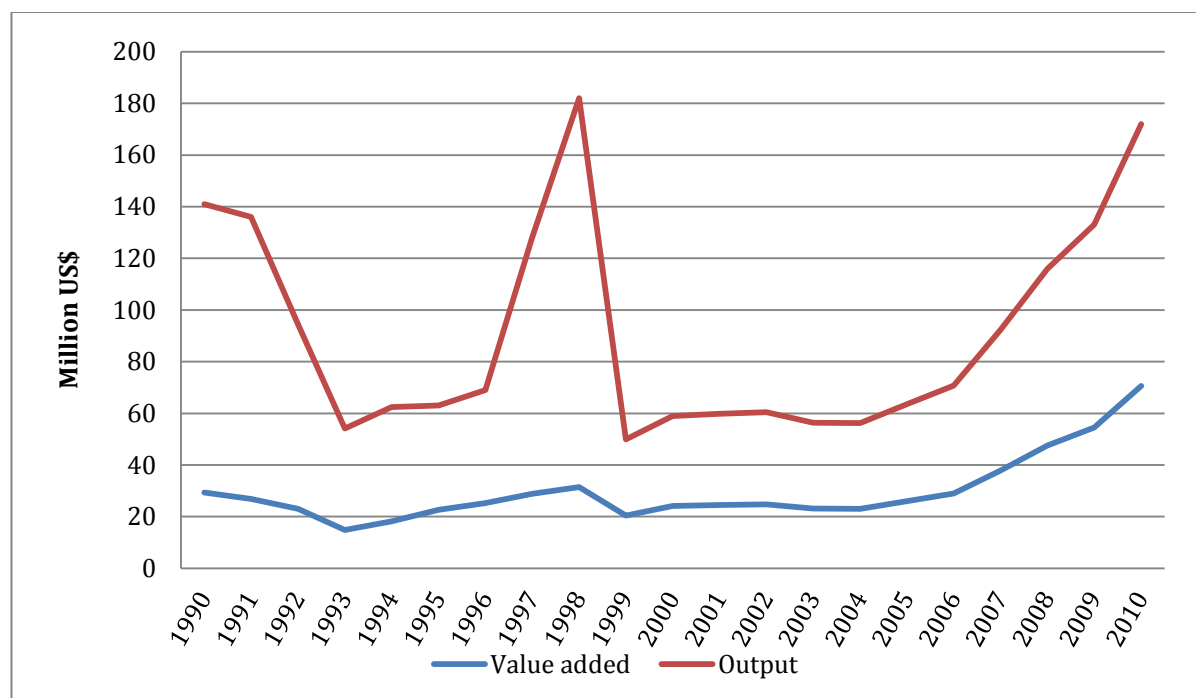
Source: UNIDO online database, accessed 9 October 2014

Trends in Kenya's furniture exports seem to support recent research (such as Edwards and Jenkins, 2014), which argues that increased trade relations between China and SSA economies have negatively affected trade between SSA economies. Figure 2.8 presents trends in Kenya's furniture exports to its major export destinations, which are mainly SSA economies (such as DR Congo, Tanzania, Uganda and Somalia). The figure shows that Kenya's furniture export to these countries generally showed an upward trend before 1997,

but stagnated between 1997 and 2004 (and even declined in the case of Tanzania). However, the exports to these countries have trended upward since 2005. This upward trend coincides with the recent upsurge in production and value addition in Kenya's furniture manufacturing sector, which Figure 2.7 portrays. This may suggest that consumers in Kenya's furniture export market have also realised that made-in-Kenya furniture offers some advantages, which may lead to higher consumer benefits than the imported furniture from China. Again, we should be mindful that the likely impact of the ban on logging on furniture production might have had a more significant effect on the trends in exports, compared to any likely changes in consumer preference in the export market.

Figure 2.8: Kenya's furniture exports by major destination
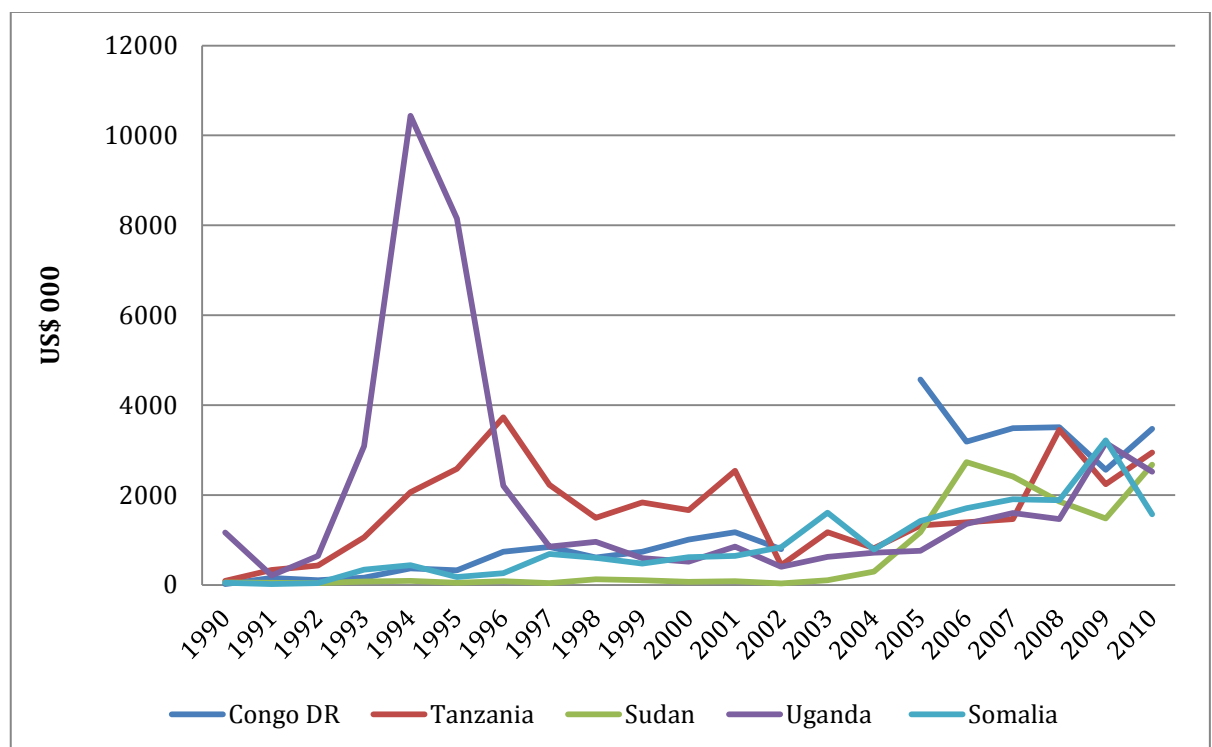
Source: UN COMTRADE, accessed on 3 October 2014

2.2.4 The informal economy and employment

ILO (1972) first delineated Kenya's informal sector, which has since attracted much interest both in Kenya and globally. Also referred to as *jua kali,* which means hot sun, the informal sector is made up of activities characterised by "ease of entry; reliance on indigenous resources; family ownership of enterprises; small scale of operation; labour-intensive and

adapted technology; skills acquired outside the formal school system; and unregulated and competitive markets" (ILO, 1972 p 6). The sector is highly heterogeneous in terms of activity areas involving enterprises in petty trading, manufacturing and services (Bigsten *at el.*, 2000).

Since the early 1970s, the sector has grown in importance, with the number of enterprises operating in the sector growing significantly. It is estimated from two national surveys that between 1993 and 1999, the number of jua kali enterprises grew from 900,000 to 1.3 million, employing 1.3 million and 2.3 million workers respectively (Kuuya, 2010). Estimates based on 2005/06 Kenya Integrated Household Budget Survey indicate that MSEs in Kenya's informal sector had increased to 1.9 million with 4.4 million workers in 2006 (Pollin *et al.*, 2008). The sector's contribution to total employment was estimated at 80.5% in 2008 representing a substantial growth over the corresponding value for 1986 which was 21.7% (Omolo, 2010). However, according to Kuuya (2010), though the performance of the informal sector has been impressive, it only offers meagre wage employment, with the majority of the workers living below the poverty line.

2.2.5 International trade pattern and relations

Generally, Kenya's economy has been relatively less open in recent years, compared to Sub Saharan Africa (SSA) as a whole. Data from the World Development Indicators (WDI) (World Bank, 2013) shows that until the mid-1990s, Kenya's total trade as a percentage of GDP was usually higher than the average for SSA; however, it remained below the SSA average throughout the noughties. Meanwhile, the gap between imports and exports of goods and services has been widening since the mid-1990s (Figure 2.9), suggesting that Kenya has become more import dependent in recent years, with negative implications for her balance of payments. It should be noted that except for a few years around the year of political independence, exports have usually been smaller than imports.

Figure 2.9: Total imports and exports of goods and services as a percentage (%) of GDP
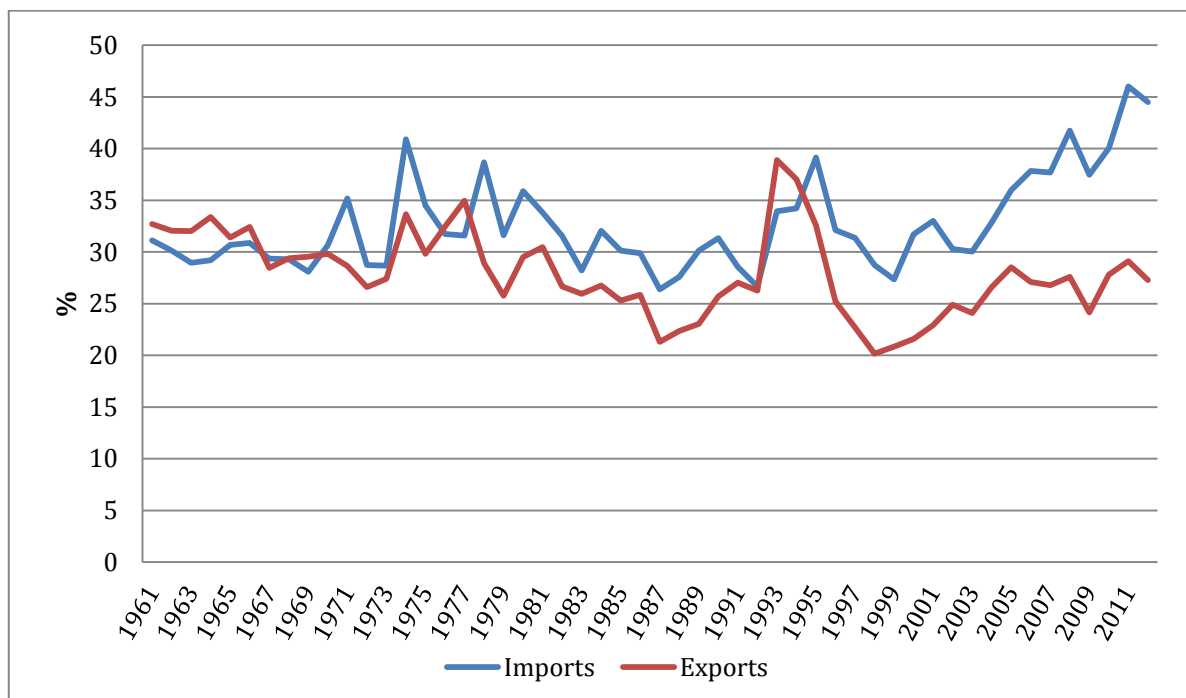
Source: World Development Indicators (World Bank, 2013)

Kenya's main export products are tea, horticulture, coffee, and manufactured goods. Major export destinations are Uganda, Tanzania, Netherlands, United Kingdom and United States (Figure 2.10). Data from UN COMTRADE show that in 2012, Uganda, Kenya's neighbour emerged as the highest trading partner in terms of Kenya's export, followed by Tanzania and then the UK. A comparison of the values of exports to the major destinations for the different years, shown in Figure 2.10, indicates that Kenya's export trade is shifting away from traditional destinations such as the UK and the Netherlands towards its neighbours (Uganda and Tanzania). The African Economic Outlook (African Development Bank e*t al.*, 2011) recognises this new trend, noting that nearly half of Kenya's export (46%) in the first eight months of 2010 went to African countries, with the main destinations being Uganda, Tanzania, Egypt and Sudan.

Figure 2.10: Major destinations for exports
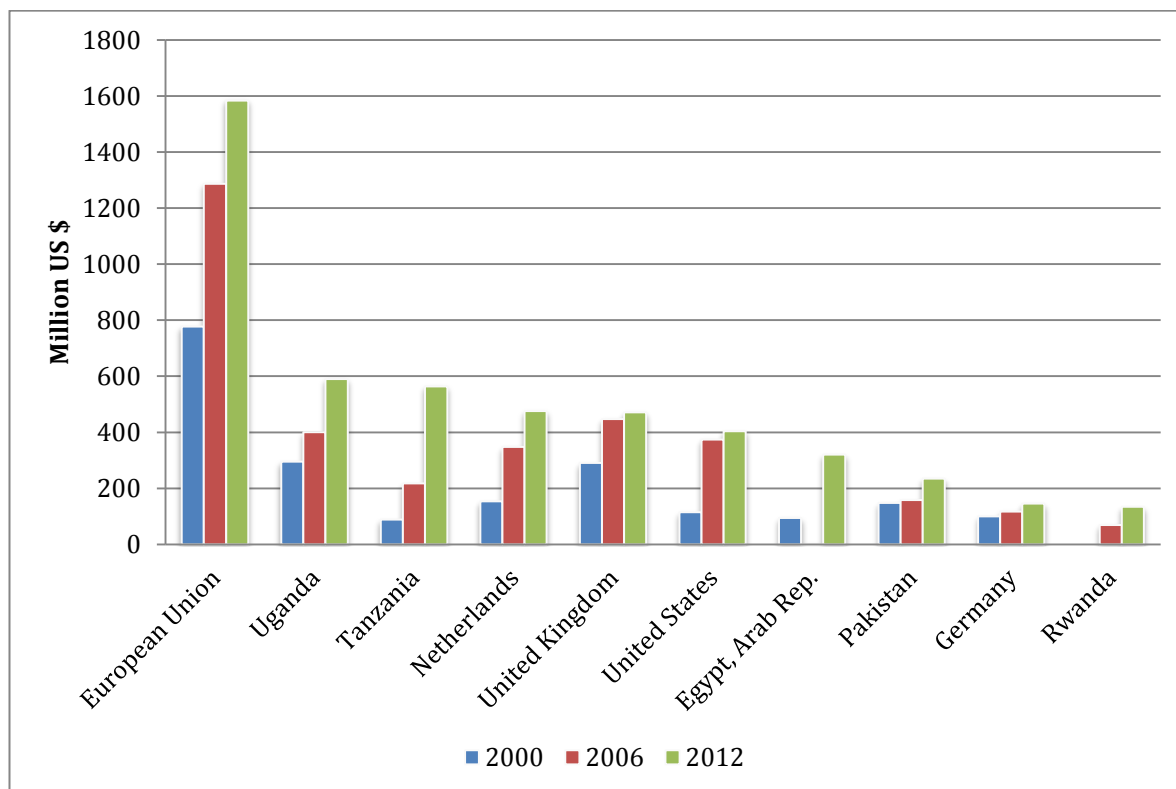
Source: UN COMTRADE accessed on 9th April 2014

Figure 2.11: Major sources of imports
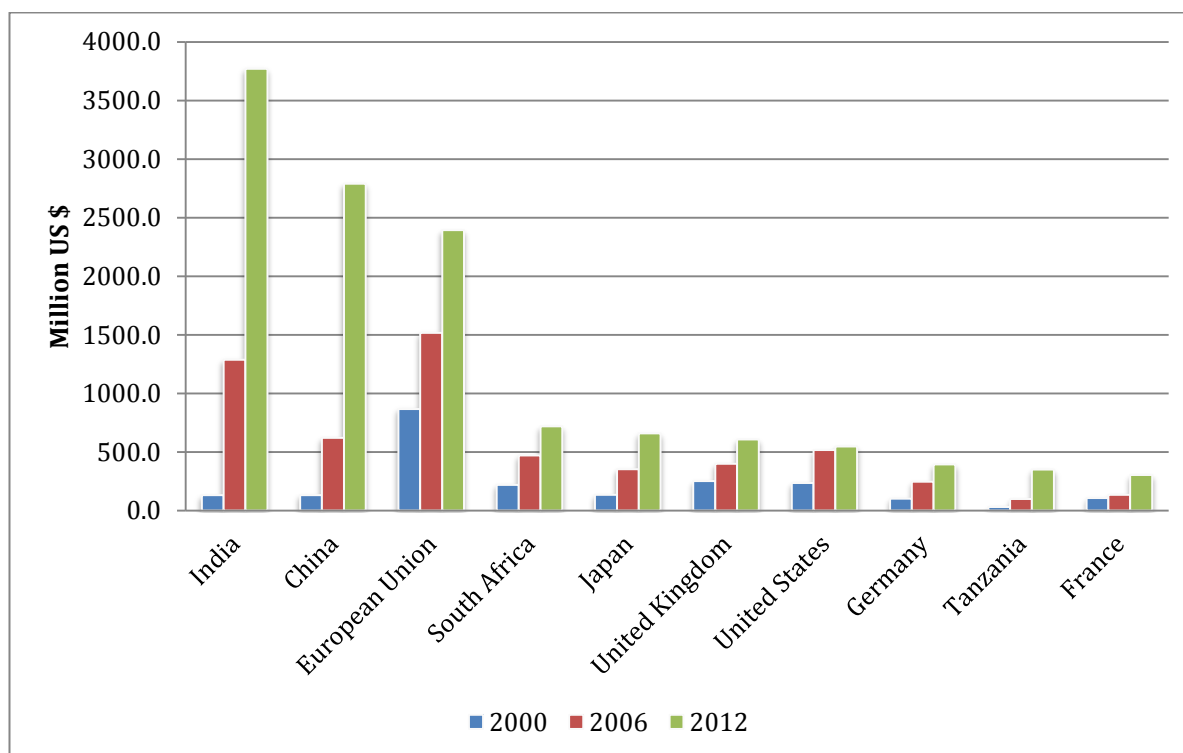
Source: UN COMTRADE accessed on 9th April 2014

Relatively, a small proportion of Kenya's export goes to Asian Driver (AD) economies (China and India). However, Kenya's imports from these economies have been very substantial especially in recent years. In 2012, the value of imports from India and China respectively stood at US $3.77 billion and US $2.79 billion, both surpassing the value of total imports from the European Union (EU) in that year, which was US $2.39 billion (Figure 2.11). Similar to the trend in exports, Figure 2.11 further shows that the AD economies have taken the place of the United States of America (USA), the UK and other advanced economies as the main sources of Kenya's imports.

Figure 2.12: Kenya's import of woodworking machines by major sources
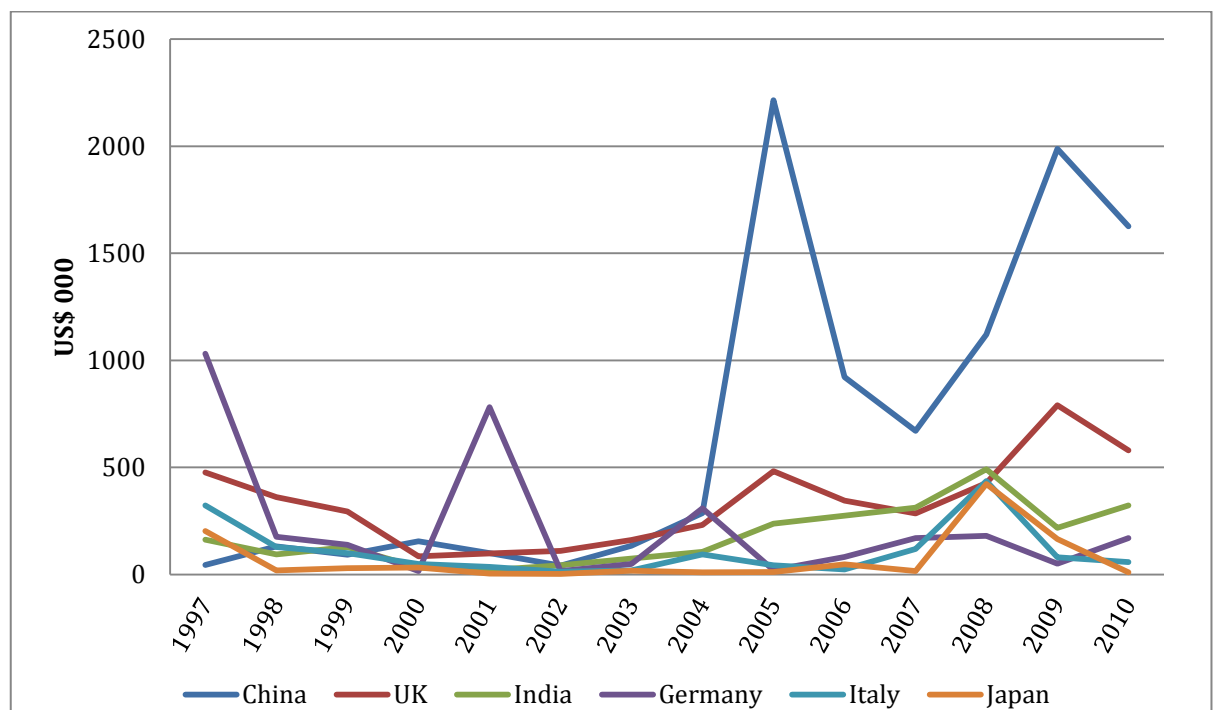
Source: UN COMTRADE, accessed on 6 October 2014

The shift in Kenya's import trade relations permeates several disaggregated import items, particularly machinery and transportation equipment (as was emphasised in Chapter 1), which in addition to petroleum products, iron and steel constitute Kenya's major import items. Figure 2.12 presents data on the trends in Kenya's importation of woodworking machinery from the main sources. The figure shows that the importation of woodworking machines from China has seen substantial growth from 2002 to 2010. A similar trend can also be observed for importation from India although the influx of Chinese woodworking machine on Kenya's

market starkly stands out. Importation from advanced countries particularly UK is still high and increasing although the trends in the data clearly indicates that imports from China now dominate Kenya's market for woodworking machines.

2.3 Social and infrastructural development

2.3.1 Demography

Kenya's population in 2010 was about 40.5 million people compared to 5.4 million in 1948 (Table 2.4). Unsurprisingly, the country had the fastest growing population globally in 1992 with a growth rate of 3.6 (Republic of Kenya, 2005a). The growth rate has however been falling with recent estimate pegged at 2.4% (Central Intelligence Agency, 2012).

Table 2.4: Population data for some selected years between 1948 and 2010

Year	Total population	Age Distribution (% of Total)			Rural/Urban Dist.		Female (% of Total)
		0-14	15-64	65+	Rural	Urban	
1948	5,400,000*						
1960	8,105,435	46.4	49.9	3.7	92.6	7.4	49.8
1980	16,267,558	50.0	47.0	3.0	84.3	15.7	50.2
2000	31,253,701	44.3	52.9	2.8	80.3	19.7	50.1
2010	40,512,682	42.5	54.9	2.7	77.8	22.2	50.1

Source: World Development Indicators (World Bank, 2011) *This figure was taken from Ikiara (1984)

The population is largely rural-based. Current estimates show that about 78% of the population live in rural areas, down from over 92% and 82% in 1960 and 1990 respectively. Consistent decline in the agricultural sector among other factors such as food, droughts, nomadic lifestyles and insecurity is largely responsible for rural-urban migration, which is high among the youth (Republic of Kenya, 2005a). The youth also constitutes a major proportion of Kenya's population. The median age for Kenya's population is estimated at 18.9 years (Central Intelligence Agency, 2012). Estimates from the WDI (World Bank, 2011) for 2010 indicate that 42.5% and 55% of the population respectively fall into 0-14 years and 15-64 years of age (Table 2.4). The high youth population together with rural-urban migration

can be linked to the level of unemployment problem in Kenya, which has over the decades largely been a youth phenomenon (ILO, 1972; Omolo, 2012).

2.3.2 Poverty, inequality and unemployment

As noted earlier, Kenya achieved high economic growth in the first two decades after independence. It has however been argued that this achievement only represented a significant stride at the macroeconomic level in that the success did not reflect in social and other development indicators. According to Ikiara (1984), not only did high levels of unemployment and increasing incidence of poverty characterise the growth process but growing inequalities, rising debt burden and slow pace of economic diversification had also become attendant features of the economy in the 1970s. Rural and urban inequalities, measured by the GINI coefficient, were respectively estimated at 38.2 and 51.8 in 1974 (Ikiara, 1984). Comparing these figures to what was reported for 1992 (see Table 2.5) shows that inequality worsened in later years. Although there was a significant reduction in the index during the 1990s, the 2005 figure presented in Table 2.5 suggests that the improvement is being reversed.

Table 2.5: Trends in poverty and inequality

Indicator	Years			
	1992	1994	1997	2005
Poverty headcount ratio at $2 a day (PPP) (% of population)	59.32	53.65	42.7	67.21
Poverty headcount ratio at $1.25 a day (PPP) (% of population)	38.42	28.5	19.57	43.37
GINI index	57.46	42.07	42.51	47.68
Income share held by the highest 10%	47.87	32.76	33.83	37.99
Income share held by the lowest 10%	1.12	2.11	2.5	1.96

Source: World Bank Development Indicators (World Bank, 2013)

Similarly, the incidence of poverty has also worsened after significant improvements in 1990s. Table 2.5 shows that the proportion of Kenya's population living on less than US $1.25 and US $2 a day fell substantially between 1992 and 1997 but increased substantially

after that period, as the 2005 figures show. As much as 43% and 67% respectively live on less than US $1.25 and US $2 per day as of 2005. This implies that the incidence of poverty has increased in absolute terms and relative poverty has also risen as inequality worsens. With respect to the first goal of the Millennium Development Goals (MDGs), Kenya is said to be off-track because a relatively high proportion of its population is still below the poverty line: Not much has been achieved in terms of halving poverty since the MDGs were adopted (African Development Bank *et al.*, 2011).

Closely related to the problem of high poverty and inequality is the high levels of unemployment, which has long been a feature of the Kenya's economy with many socio economic implications. The unemployment rate was officially estimated at 12.7% in 2005/06, compared to 14.6% in 1998/99 (Wambugu *et al.*, 2009). However, a broader definition of unemployment, which includes those who would like to work but have given up looking for work, indicates that the unemployment rate was 40% in 2008 (Central Intelligence Agency, 2012). Of this figure, an estimated 64% are youth (Sauder School of Business, 2009). According to Wambugu *et al.* (2009), the high unemployment, particularly among the youth, was a major factor that fuelled the post-election violence in 2008.

Associated with the high unemployment is the fact that the country's GDP-employment elasticity has declined from an estimate of 1.28 for 1992-1996 to 0.5 for 2004-2008 (Omolo, 2012). This means that the amount of employment created from a given percentage increase in GDP has diminished substantially between the two periods. The implication is that economic growth in recent years has delivered relatively limited opportunities for absorbing the increasing number of the unemployed youth in Kenya. This trend may partly account for the bleak and worsening poverty and inequality profile of the country in recent years.

2.3.3 Education and human resource

One likely reason for the high levels of unemployment in Kenya is the limited access of the youth to formal education. Data from the WDI (World Bank, 2013) indicates that the literacy

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rate among persons over 15 years old was 72% in 2007, which is 10 percentage points down from the figure in 2000 (82%). It is also estimated that only 55% of about 600,000 pupils who complete primary school each year are able to enter secondary schools and the number that proceeds from secondary schools to universities greatly diminishes (Nyerere, 2009). To deal with this problem, the government has in recent years promoted Technical, Industrial, Vocational and Entrepreneurship Training (TIVET) to absorb the large number of people who are not able to progress to secondary and higher level education. Special institutions such as Youth Polytechnics, Technical Training Institutes, Institutes of Technology and National Polytechnics run TIVET programmes in Kenya. Enrolment in these programmes increased from 62,439 in 2003 to 76, 516 in 2007, representing 22.5% increase within that period (Nyerere, 2009).

2.3.4 Infrastructure

Kenya has a significant infrastructural deficit, which requires a sustained expenditure of nearly US$ 4 billion per annum for at least a decade (World Bank, 2010; Briceño-Garmendia and Shkaratan; 2011). The available infrastructure is also not equitably distributed across the country's regions. With the population and agricultural activities being highly concentrated in the southern part of the country, infrastructural development (especially road, power transmission, and ICT) have considerably favoured the southern sector (World Bank, 2010).

Power supply remains highly unreliable because the installed power generating capacity is limited, making electricity supply the country's greatest infrastructural challenge (World Bank, 2010). As indicated in Table 2.6, the installed capacity is very low, over 20 times less than the average for middle income countries (MICs) in Africa, which has translated into high levels of power outages with high losses for firms operating in Kenya. Road density in Kenya is also significantly less than the average for MICs in Africa although Kenya appears to be better than its low income country (LIC) counterparts (Table 2.6).

Table 2.6: Power and road infrastructure for Kenya and Africa's LICs and MICs

Description	Unit	LICs	Kenya	MICs
Power				
Installed power generation capacity	MW/million people	24.4	33	796.2
Power outages	Day/year	40.6	53	5.6
Firms' reliance on own generator	% of consumption	17.7	15	0.5
Firms' value lost due to power outage	% of sales	6.1	3	0.8
Road				
Paved road density	KM/1000km2 of arable land	86.6	152	507.4
Unpaved road density	KM/1000km2 of arable land	504.7	930	1038.3
Perceived transport quality	% firms identifying road as a major business constraint	23	37	10.7

Source: World Bank (2010) based on the World Bank's Africa Infrastructure country diagnostic (AICD) survey, conducted in 2006/08.

Figure 2.13: Internet users and mobile phone subscription
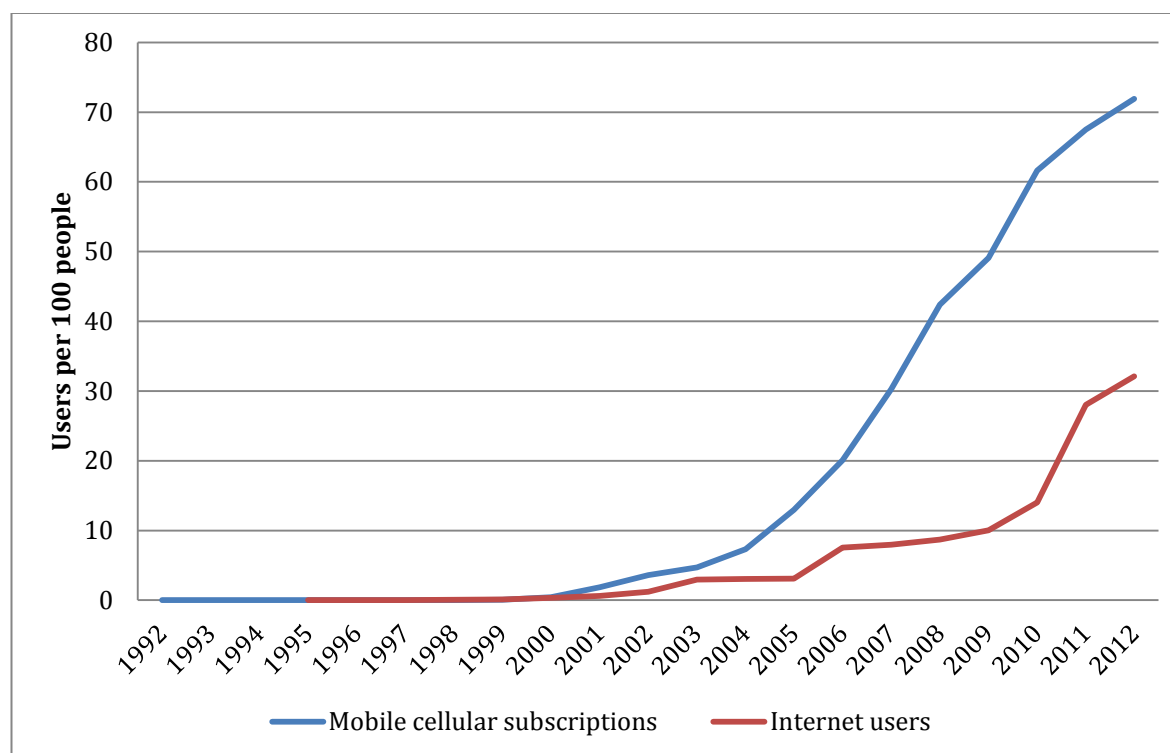
Source: World Development Indicators, World Bank (2013)

For ICT, however, the picture appears reassuring. Figure 2.13 provides an indication of the level of ICT infrastructure in Kenya in terms of Internet users and mobile cellular subscription

per 100 people. The data show significant increases in both indicators especially mobile cellular subscription over the last decade. Over 70% of the population have subscribed to mobile cellular networks as of 2012, compared to less than 2% in 2001. Thirty-two percent (32%) of the population uses the Internet, representing a substantial increase over the 2001 figure which was less than 1%.

2.4 Technology in industrial/development policies

Employment creation and poverty reduction have together constituted a major theme of policy objectives enshrined in Kenya's development and industrial policy documents. From the first *National Development Plan, 1966-1970* to the *Economic Recovery Strategy for Wealth and Employment Creation, 2003-2007* and *Vision 2030* (First Medium Term Plan, 2008-2012), the government has sought to implement policies to fight unemployment and extreme poverty. Industrialisation has been seen as the major means to address the main development challenges of unemployment and extreme poverty (Ronge and Nyangito, 2000). The emphasis on industrialisation is more pronounced in the *Sessional Paper No.2 of 1996 on Industrial Transformation to the Year 2020* and *Kenya National Industrialisation Policy Framework, 2011-2015* (which is anchored on the *Vision 2030* – the current policy and long-term development plan), compared to previous policy strategies such as those prescribed in the *Sessional Paper No. 10 of 1965*, which appears to give prominence to both industry and agriculture.

A major downside of the earlier policy strategies is that the level of attention given to technology choice appears to have been limited, suggesting that little recognition has been given to the implication of suboptimal technology choices for development. This can be seen in the effect of the IS policy regime. In addition to the disadvantages mentioned earlier in subsection 2.2.1, there is a belief that the IS policy largely neglected technological capability building in micro and small enterprises while favouring large scale manufacturing firms that used imported and relatively capital intensive technologies and were mostly established with private foreign capital – foreign direct investment (FDI). Such FDI-based firms operate in the

formal sector and tend to have limited linkages with the informal sector leading to minimal technology spill-over effects (Meilink, 1982). They also constitute a threat to indigenous entrepreneurship especially in later stages of their development, partly explaining why indigenous firms do not grow into large enterprise (Kabecha, 1999; Nyong'o 1988; Meilink; 1982). Accordingly, studies have shown that about a third of the micro and small enterprises fold within three years after establishment (Kuuya, 2010).

The limited attention given to indigenous entrepreneurship, and technology and innovative capacity development clearly reflects in the data on patent and trademark application in Kenya (Table 2.7). The table shows that patent applications have been generally low since independence, with most of the applications coming from non-residents. Similarly, for trademarks, the number of applications from residents has been consistently lower than that from non-residents since independence except for the period 2005-2010. The data in Table 2.7 therefore point to a generally low degree of innovative activities in Kenya.

Table 2.7: Patent & trademark applications and scientific & technical journal articles

Year	Scientific and technical journal articles	Patent application		Direct trademark application	
		Non-residents	Residents	Non-resident	Resident
1965-1974		114		714	170
1975-1984		99		661	424
1985-1994	275	70	8	561	415
1995-2004	251	45	24	909	608
2005-2010	260	81	45	734	1344

Note: Figures are computed averages for the specified period.

Source: Calculated from WDI, World Bank (2013).

Information presented in Table 2.8 on Kenya's production of machinery and equipment and the level of importations of the same items seems to confirm the belief that innovative activities or capabilities are relatively in Kenya. For all the items presented in the table, domestic production was considerably lower than imports for each year. For medical, precision and optical instruments, there are no production values for Kenya in the UNIDO

database. Moreover, there was no data on this item on Kenya National Bureau of Statistics bulletin on manufacturing subsectors' aggregates, indicating that production of such items in Kenya may be negligible even if it exists.

Table 2.8: Kenya's production and imports of machinery and equipment in million US Dollars

Product description	ISIC	Year		
		2000	2003	2006
Kenya's total domestic production (A)		221	261	494
Machinery and equipment n.e.c.	29	12	24	149
Electrical machinery and apparatus	31	70	80	113
Motor vehicles, trailers, semi-trailers	34	139	157	232
Kenya's total import from the world (B)		612	618	1319
Machinery and equipment n.e.c	29	230	250	472
Electrical machinery and apparatus	31	178	61	163
Medical, precision and optical instrument	33	38	46	82
Motor vehicles, trailers, semi-trailers	34	166	261	603
Domestic output plus imports (A+B)		833	879	1813
B as a percentage of A+B		73	70	73

Source: Trade and production data were respectively extracted from UN COMTRADE and UNIDO online database.

Table 2.8 further shows that the Kenya's importation of equipment and machinery constitute over 70% of the sum of domestic production and imports. It should however be noted that because of the relatively high degree of informality in indigenous entrepreneurship, the data in Tables 2.7 and 2.8 may not adequately reflect the scale of innovative activities in Kenya. Nevertheless, the evidence that indigenous technology and innovation capability appears rudimentary suggests that Kenya's industrialisation and development efforts may have to extensively depend on imported technology while developing and mainstreaming indigenous innovation and technology. But the idea that technologies from advanced countries are generally inappropriate for developing countries raises the question of whether emerging economies particularly China offer a better alternative.

In recent years, policy has given some attention to indigenous technology and how to harness it for development. An example is the Science, Technology and Innovation (STI) Policy Strategy (Republic of Kenya, 2008b), which is an addendum to Kenya's Vision 2030. The STI strategy emphasises the need to:

> Exploit the full potential of science, technology and innovation to protect, preserve, evaluate, update, add value to, and utilise the extensive indigenous resources and traditional knowledge available in the formal and informal sectors of the economy for enhanced livelihoods for various Kenyan communities (Republic of Kenya, 2008 p 33).

Unlike the IS regime, recent policy strategies also appear to recognise that the nature of technology choice matters if industrial growth and development will create or enhance employment opportunities in Kenya. For example, the *Sessional Paper No. 2 1996* asserts that "Kenya must be selective in acquiring its technology … the pursuit of technology that is efficient but creates little or no employment is not appropriate" (Republic of Kenya, 1996 p 63). For technology transferred through FDI, the document notes: "the Government would give attention to the nature and conditionalities surrounding the importation of technology" (Republic of Kenya, 1996 p 64).

Furthermore, more recent policy documents particularly *Sessional Paper No. 2 of 2005 on Development of Micro and Small Enterprises for Wealth and Employment Creation for Poverty Reduction* has also given prominence to the development of the technological capacity of MSEs. The goal is to enhance the ability of MSEs to adopt and adapt new technology and to improve their access to available technology. For this category of businesses, the government appears to have recognised the potential of technologies from emerging economies. According to the *Sessional Paper No. 2 of 2005*, "…Government will provide steady alternative sources of technological inputs into the sector [MSEs] through the importation of relevant technologies from other countries such as India, South Korea, Pakistan and China" (Republic of Kenya, 2005b p 30).

2.5 Conclusion

The above discussions show that Kenya is a low-income economy, and high levels of extreme poverty, inequality and unemployment have characterised the economy since political independence. Rather than improving, the unhealthy socioeconomic circumstances appear to have worsened in recent years particularly with regards to poverty and inequality. This undesirable state of affairs is associated with several factors such as poor economic growth performance and major infrastructural deficits especially with respect to power supply. Other factors include the lack of pro-poor industrialisation process and proper policy attention to micro and small enterprise especially those operating in the informal sector, which accounts for about 80.5% of employment in Kenya. Another important correlate of the ills has been a political system that is not robust and fuels ethnic sentiments while conditioning the nature of policy configuration and negatively affecting trends in socio economic development.

The discussion has also shown that indigenous technology and innovative capacity in Kenya appears low, suggesting that the country may have to depend extensively on imported technology while developing and mainstreaming indigenous technology. The need for importing technology and the choice set for the sources of importation bring to the fore the issue about the changing pattern of Kenya's international trade relations. The new pattern is that there is a rapidly growing trade relation with other developing or emerging economies, particularly India and China as major sources of imports, and the neighbouring countries such as Uganda and Tanzania as major export destinations, positions that were initially for advanced countries.

Lastly, recent industrial and development policy appears to give relatively more attention to technology choice, recognising the distinctive technology needs of micro and small enterprises although in a sketchy manner. Also, the current policy environment generally appears to have a relatively higher consideration for micro and small enterprises than what existed earlier. The next chapter presents a review of the literature relevant to the subject matter of this thesis.

CHAPTER 3 : LITERATURE REVIEW

3.0 Introduction

Despite pessimism such as those from Thomas Malthus[8] and the writers of "The Limits to Growth"[9] (and more recently rejuvenated by Richard Heinberg[10]) about the constraints nature places on economic development, global per capita income has seen significant increases, particularly in the last century, thanks to technological progress. Thus, one cannot overemphasise the role of advances in technology in mankind's effort to overcome significant and life-threatening challenges. But what is technology and how can it be harnessed to overcome the persisting global challenges particularly poverty, unemployment and inequality? With this broad question in mind, this chapter presents a review of the literature on several issues on technology with a view of isolating concepts and facts that will provide a conceptual or theoretical background to the empirical work used for answering the three basic research questions raised in Chapter 1.

The chapter first explores ambiguities surrounding what the term *technology* is associated with. This is followed by a discussion on the question of whether some technologies may produce desirable socioeconomic outcomes, for example, with respect to poverty and employment, compared to others. Hence, the discussion mainly addresses the literature on *technology choice,* its associated concept of *appropriate technology* as well as the determinants of technology choice. After this follows a discussion on the sources of technical change and inducement to technical change, which among other factors represent a rationalisation of the likelihood that inappropriate technologies may exist. The discussion then moves into issues surrounding technology transfer and transfer mechanisms. The

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[8] In his book, "An Essay on the Principle of Population", published in 1798, Malthus questioned the capacity of the earth to allow for increasing standard of living.

[9] At the instigation of the Club of Rome on its project "The Predicament of Mankind", Meadows *et al.* produced a report titled, "The Limits to Growth", in 1972. The report laid emphasis on the earth as an ecological system having limited potential to meet the growing economic demands placed on it, hence, the need to place limits on the extent to which man exploits the gift of nature.

[10] In his book titled, "The End of Growth: Adapting to the New Economic Reality", published in 2011, Heinberg argues that further growth in the global economy is not possible and only relative growth (i.e. growth in certain regions or countries) is possible, with the global economy playing a zero-sum game.

chapter ends with a summary of the salient issues and a highlight of the gap in the empirical literature, which this thesis aims to fill.

3.1 What is technology?

The term technology has been used loosely to describe different but related concepts in the literature to the extent that the use of the term is shrouded in ambiguities. Thus, it is not surprising that Norman Clark, based on Cooper and Sercovitch's (1971) work, indicated that "…'technology' is not a homogenous concept but is rather a term connoting a wide range of heterogeneous forms or 'elements'…"(Clark, 1985 p. 183). Writing in the late 1970s, however, Winner noted that in the decades before the time of his writing, technology had a specific and unproblematic meaning in academic and everyday discourse, being used to refer to "practical arts" either individually or in a collective sense and the study of them (Winner, 1978). He further noted that this had changed at the time of his writing such that the term had lost its precision and taken on a ubiquitous nature, leading him to assert: "There is a tendency for those who write or talk about technology in our time to conclude that technology is everything and everything is technology … the word has come to mean everything and anything … [and] threatens to mean nothing" (Winner, 1978 p 9-10). In corroborating Winner's observation, Willoughby (1990) indicated that the last century has seen the term expand from something of a limited meaning to one characterised as an all-embracing symbol or concept.

The evolution of the broad meaning associated with technology, according to Winner (1978), may have started with a definition by the 1909 *Webster's Second International* unabridged dictionary, in which technology is said to be "industrial science, the science or systematic knowledge of the industrial art, especially of the more important manufactures" (cited in Winner, 1978 p 8). It should however be noted that an earlier characterisation of technology by Karl Marx was also relatively broad but to the extent that Winner did not mention it may indicate its relative unpopularity compared to the Webster's definition. Marx in his book, *Capital: Critiques of Political Economy,* first published in 1887, said "Technology discloses

man's mode of dealing with nature, the processes of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them" (Marx, 1887 p. 326). Whomever the broad definition originated from, by the 1950s and 1960s many writers had started propounding definitions, which significantly extended the scope of the term. Most of those studies therefore tended to depict technology as a concept with a meaning much greater than the hardware, machines or individual apparatus normally associated with technology in earlier popular thinking (Willoughby, 1990).

For example, Ellul defines technology as the "totality of methods rationally arrived at and having absolute efficiency (for a given stage of development) in every field of human activity" (1964 p 26). Although Ellul (1964) specifically mentioned using the above phrase to describe *technique* rather than technology, his description is generally consistent with significant aspects of definitions of technology offered by other authors such as Stewart (1982). Stewart (1982) describes technology in a broad sense although no emphasis is explicitly placed on the nature of efficiency as an essential condition. Stewart identifies technology not only with the hardware of production which includes knowledge about machines and processes, but as a concept which encapsulates the skills, knowledge and procedures for 'making, using and doing useful things'. For Stewart, technology includes methods used in both marketing and non-marketing activities: production, managerial and marketing techniques; product design and how they are produced; manufacturing, agriculture and services (e.g. administration, education, banking and the law); and the organisation of productive units (Stewart, 1982).

Others have stressed knowledge as the main defining characteristic of technology. MacDonald (1983) for example refers to technology as the sum of knowledge, which allows things to be done but frequently through the use of machines (not always, though) and the information the machines possess. In a more recent work, Mokyr starkly observes that "Technology is knowledge" (2005 p 1120), essentially reducing the relationship between technology and knowledge to a mathematical equality. However, Mokyr further notes that the basic unit of analysis of technology is the technique, which he defines as the set of

instructions for producing goods and services, and decoupled the techniques from artefacts or machines. In his example, a piano is an artefact; however, what one can do with it depends on the technique the user employs, suggesting that a technique is never the same as the artefact, which aids the deployment of the technique. Contrarily, Willoughby defines technology as the "ensemble of artefacts intended to function as relatively efficient means" (Willoughby, 1990 p 38). He shows that the phrase "function as relatively efficient means" helps to avoid the tendency of equating technology to artefacts and helps to isolate artefacts that are technological from those that are not.

Thus far, artefact-based and procedure/ technique-based definitions have been mainly identified. Rather than being competing ways of defining technology, Dosi and Grazzi (2009) have suggested that the latter representation in many ways complements the former and emphasised the usefulness of the artefact-based definition in two respects: (1) it allows for the dynamic study of innovations which takes place by improving or modifying the performance characteristics of each component of the artefact and the whole artefact; and (2) it helps to identify the technical and economic characteristics of specific products, machines, components and intermediate inputs. They however acknowledge the broader scope of the procedure-centred definition by observing that it applies even when technology cannot be represented in the form of a tangible artefact.

The apparent ambiguity, also fuelled by semantic difficulties, led Winner (1978) to avoid any attempt to define technology in any concrete or selected terms. Rather, he provided a typology for the term, based on the different emphases highlighted by different writers. In his typology, technology refers to *apparatus, technique, or organisation (and even the network between organisations)*. Apparatus represents all objects described as technological such as tools, instruments, machines, appliances, weapons and gadgets, which are used for performing a variety of activities. This description corresponds with what other writers have referred to as artefacts. Techniques refer to the body of activities involving skills, methods, procedures and/or routines used for accomplishing tasks. This definition closely aligns with Stewart's and Ellul's conceptions about techniques discussed above. In a similar fashion to

Stewart, Winner represents organisations as diversities of technical, rational and productive social arrangements; however, Winner (1978) recognises the network between different productive units as an essential organisational form.

As a result of the lack of consensus on what technology stands for, Chapter 4, among other things, provides an operational definition of technology as used in the empirical work of this thesis.

3.2 Technology choice

Apart from being somewhat elusive to define, controversies have existed about the benefits of technology for human existence and ecosystems in both academic and policy circles. Referring to those who hold up the positives of technology as "boomsters" and their opponents as "doomsters", Ruttan (2001) indicates that commentators (especially those across disciplines) on technological change have largely not agreed on its actual and potential impacts. According to Heertje (1977 p 1-2), "some authors stress the prosperity that technical change brings, whiles other stress its horrors … terrifying wars that modern sophisticated weapons permit". Broadly, however, it is within this controversy that the concept of technology choice appears to derive its essence (Willoughby, 1990). Willoughby indicates that technology choice "may be seen as an attempt to get beyond the simplistic options of either uncritical acceptance or uncritical rejection of technology" (1990 p 5) and that its use as a focus for analysis acknowledges the existence of inappropriate technologies, around which critical issues converge. In the subsections that follow, a few of the analytical framework for technology choice identified in the literature are reviewed, with a view to addressing the specific elements of technology and techniques which are relevant to this thesis' enquiry. The subsequent discussions therefore focus on the representation of technology and technique in the economics literature.

3.2.1 The neoclassical approach

In the neo classical framework, technology choice is made from an infinite set of technically efficient techniques. The framework is based on a number of assumptions: The state of technological knowledge is defined by a continuous production function (for a given level of output, say Q, such a production function can be represented by the curve QQ – also referred to as *isoquant* – as in Figure 3.1); there are two factors of production – capital and labour – which are homogenous in producing homogenous products; and factor and product markets are perfect so that the factors of production are rewarded with the value of their marginal products. The consequence is that in producing Q, for example, capital and labour could be combined in an infinite number of ways with no regard to the level of returns to scale. Each point in the labour-capital space shown in Figure 3.1 represents a technique, of which the technically efficient ones are those lying on the isoquant, assuming a given level of technological knowledge or advancement. Points to the right of the curve, for example point A, are technically inefficient in that to produce the same level of output Q requires an increase in the quantity of, at least, one of the factors. Techniques to the left of the curve, such as point B, are not available or have not been developed, that is, the state or level of existing technological knowledge is inadequate to produce such techniques. The neoclassical model therefore regards technology choice as deciding between technically efficient techniques of varying factor intensities.

Making a choice from a technically efficient set of techniques requires profit-maximising firms (which do not differ in characteristics) to select technically efficient combinations of capital and labour that produce the minimum cost of production. This condition is satisfied at point P_1 in Figure 3.1 where line EE (namely, *isocost*), representing the relative factor price, is tangential to the isoquant. The technique associated with point P_1 is referred to as an *economically efficient* technique. The effect is that the relative factor price of labour and capital and the degree of substitutability between the factors (i.e. the slope of the isoquant) become the only determinants of choice. With a given production function, the relative factor price therefore becomes the sole determinant of technology choice.

Figure 3.1: Technical and economic efficiency
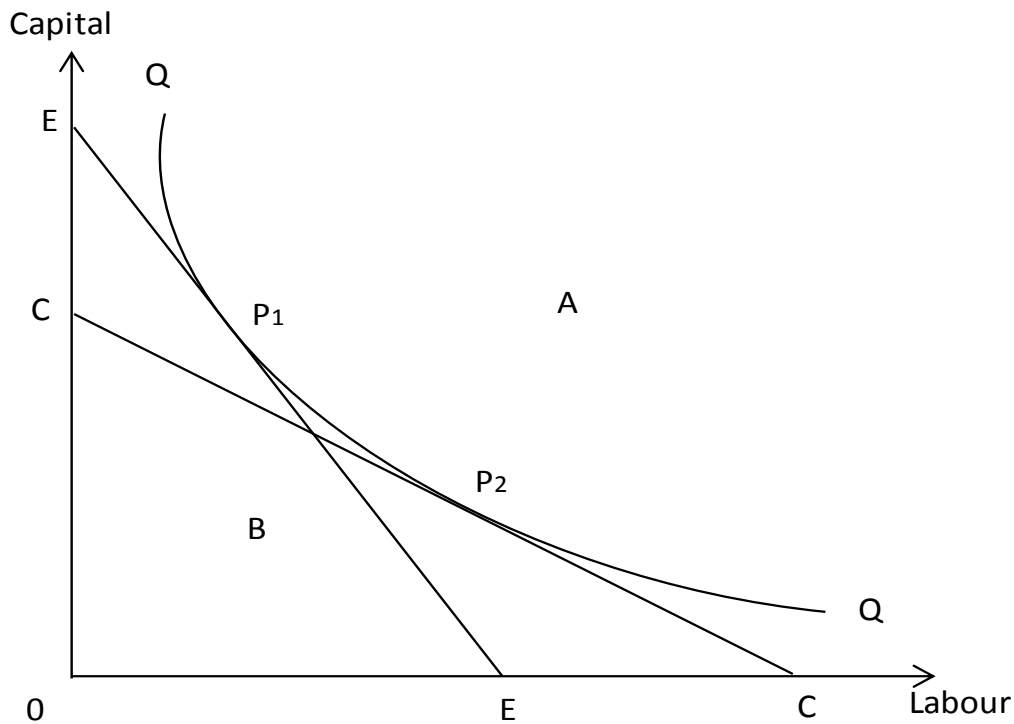
Source: Clark (1985)

A change in the relative factor price alters the choice as illustrated by the addition of a second isocost in Figure 3.1. If the isocost the firm faces is CC instead of EE, then, P_2 will be the economically efficient point. Acemoglu and Finkkelstein (2008) provide an example of empirical evidence on this outcome. These authors examined the effect of an increase in the relative factor price in the US public hospital service which resulted from a change in the government's regulatory framework for the sector in 1983. The change involved a move from full cost to partial cost reimbursement for hospital inpatient expenses on Medicare (government-subsidised) patients. Under the new regime, only expenditures on capital inputs are reimbursed with labour expenses covered by the fixed price paid per unit of output. The consequence, according to the authors, was an increase in the relative price of labour inputs (among others), which led to an increase in the capital-labour ratio (i.e. a change in technique). However, they observed that the change in the capital-labour ratio resulted in a reduction in labour inputs but with no change in the capital inputs, suggesting that new and

more efficient technologies (capital goods) were adopted to replace labour inputs in the face of the change in the relative price of labour. Diagrammatically, this involves a movement to a new isoquant to the left of QQ.

An additional important implication of the outcome of the neoclassical framework is that insofar as relative factor prices reflect factor endowment, countries with different factor endowments will choose different techniques. That is, capital-endowed countries will select capital-intensive techniques while labour-endowed countries will select labour-intensive techniques (Clark, 1985).

Shortfalls of the neoclassical approach

The neo classical model has been described as a special case, which has limited relevance in practice (Stewart, 1982). Many of the criticisms are associated with the realism of some of the assumptions underlying the model. Some of the shortfalls are discussed in the paragraphs that follow. While the discussion highlights these shortcomings, it also helps unravel other factors, which in addition to relative factor price are important to understanding the nature and outcome of a technology choice.

1. Factor prices may not be perfect in the real world, with the effect that the prevailing relative factor price may deviate from that of the perfect competition scenario. Reasons cited for this includes information asymmetry in factor markets, monopoly control of resources and minimum wage legislation (Clark, 1985). For similar reasons, product markets may also not be perfect. Moreover, with the recent trend of firms pursuing product differentiation engineered through several marketing, advertising and branding strategies, products themselves cannot be homogenous. The breakdown of these assumptions compromises the economic or allocative efficiency of the choice with the implication that developing countries, for example, may select capital-intensive techniques in the presence of relatively high labour abundance or unemployment.

Another factor identified as being a culprit for distortion in relative factor price is *shirking* – a moral-hazard situation where workers do less than what they agreed on with their employers. Using empirical data on private farms, operating in Jewish Palestine, Depken II *et al.* (2001) show that while shirking is a likely reason for distorted relative factor prices, it also leads to greater labour hoarding, an evidence for technical inefficiency. They concluded that when shirking causes allocative inefficiency, then technical inefficiency arises endogenously as a rational response.

2. The model tends to ignore any influence that scale of production may have on choice of techniques. Scale can lead to an important difference between the efficiency of different techniques even if factor prices remain unchanged or are not distorted (Stewart, 1982; Kaplinsky, 1990). Consider two techniques of different scales – A and B – as shown in Figure 3.2. The minimum cost of A is higher than that of B. However, an important relationship between them is that the minimum cost of B is associated with relatively high output level (Q_3) compared to that of A (Q_2). For output levels less than Q_2, for example Q_1, technique A produces a lower cost than technique B. This suggests that for firms operating in smaller markets (especially those in developing countries) technique A is economically more efficient than technique B. A recent study by He *et al.* (2012) confirms that market size affects the choice of technology. In a game theoretic framework for a duopoly, they found that an increase in market size increases a firm's willingness to invest in a more expensive but flexible technology that produces differentiated products.

Figure 3.2: Scale of production and average cost

Cost per unit
of output
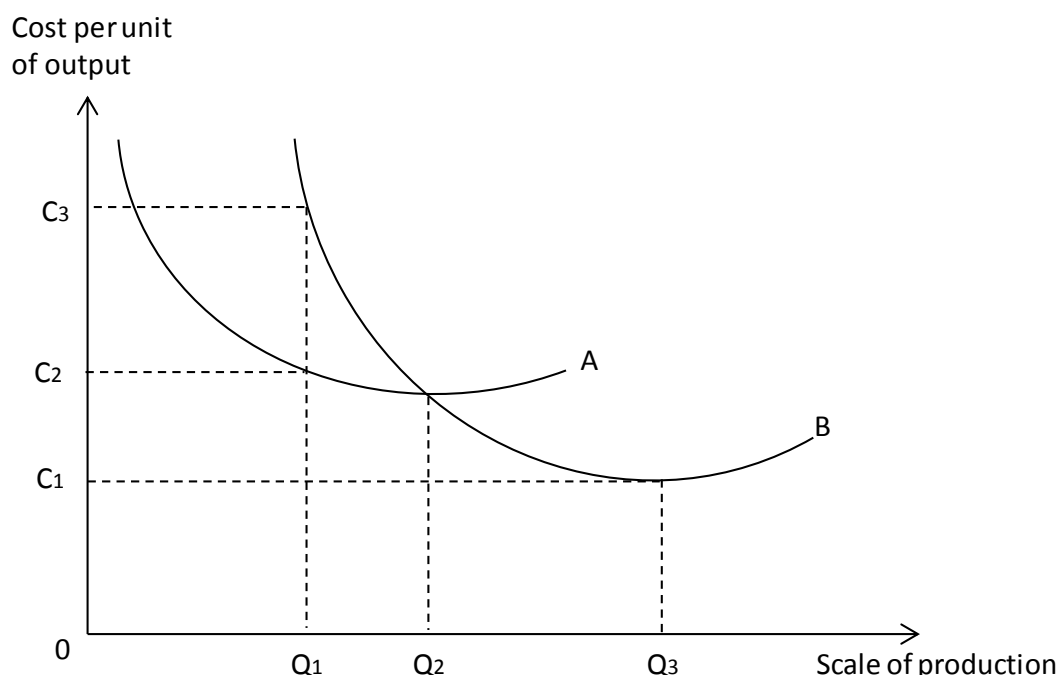
Source: Kaplinsky (1990)

3. Obviously, capital and labour are not the only input in production and may not be homogenous. Other factors such as materials, energy, general infrastructure (e.g. good roads and telecommunication network), land, semi-processed materials and services are also important (Stewart, 1982). The homogeneity assumption also renders the decision-making problem too simple because it "helps" to neglect the qualitative differences within the broad categories of inputs (capital and labour) we observe in the real world. Such differences should not be ignored although they pose empirical difficulties in measuring or aggregating the factors of production (Robinson, 1953).

4. Moreover, the assumption of a continuous production function, which allows for an unlimited range of efficient techniques for producing a particular product, has been contested (Rosenberg, 1976; Nelson; 1980; Stewart, 1982). Stewart (ibid) provides a number of reasons to justify why this does not reflect reality. First, techniques available for selection at any point in time consist of techniques which have been developed at different time period in the past, with earlier techniques being more labour intensive and having less scientific and technical knowledge and relatively low technical

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efficiency. Consequently, "… far from there being a complete isoquant corresponding to each moment of time, for each scientific and technical age, … there is a series of techniques developed at different times with a tendency for the earlier ones to become technically inefficient" (Stewart, 1982 p 27). Second, later techniques tend to be scale intensive and demand relatively high quality inputs; hence, it is unlikely for new and old techniques for producing a particular output to lie on the same isoquant. Third, process techniques vary over time with resultant products also going through systematic changes with time; hence, later process techniques produce more efficient and higher income products than earlier ones. The implication is therefore that techniques of varying factor intensities that produce the same product with the same technical efficiency may not exit in the real world. Stewart's argument aligns with Rosenberg's position that "the notion of a wide range of …[techniques], as implied by the drawing of smooth, continuous isoquants, is largely a fiction" (1976 p. 63).

5. The model is also based on an unrealistic assumption that the choice is made by only one type of decision maker (the firm), which has the sole objective of maximising profit (Ruttan, 2001). In reality, however, decision makers may differ in terms of motive, knowledge (especially in the world of information asymmetry) and may face different constraints (Stewart, 1982).

3.2.2 Stewart's Approach

In response to the limitations of the neoclassical model, Stewart (1982) provided a theoretical framework for analysing the determinants of technology choice. Following her definition, as mentioned in Section 3.1, Stewart distinguished between technology available to a particular country and technology in use in that country. Technology available to a country refers to the body of techniques that the country potentially has knowledge about and would be able to acquire. These techniques constitute a subset of all known techniques in the world. Technology in use, on the other hand, consists of a subset of the available techniques the country has acquired. A country may not have access to all known techniques in the world

and that is usually the result of weak communication restricting the international diffusion of some of the world's techniques. Another reason is that techniques may be known but they may not be available to a country because no one is producing the machinery or other inputs required. These two factors, according to Stewart (1982), limit the options in the technology basket available to a country.

However, the diffusion of certain techniques may also be limited by other factors such as institutional protection (property rights) and corporate secrecy. This omission however does not limit the main conclusion from Stewart's analysis, which is: "If the technology in use is thought to be inappropriate, it may be inappropriate because world technology is inappropriate or because inappropriate subset is available to the country or because inappropriate selection is made or for some combination of the three reasons" (Stewart, 1982 p 3).

How the above conclusion was reached is illustrated in Figure 3.3. From the figure, technology available to a country depends on the technology known in the whole world. The actual technology adopted is then determined by the available set of technologies and other factors, which constrain the selection mechanism. Each technique in the available set is associated with a set of characteristics, which have been conditioned by historical processes that underpin technology development. The historical processes reflect changes in the organisation of production, income levels (and distribution) and technical factors, which vary with time and across places. The entities which make technology choice in any given period are not homogenous: They differ with respect to their objectives, knowledge and circumstances relating to scale of production, market, access to finance etc. The aim of each decision maker is to maximise an objective function, subject to some constraints (available technology, markets, scale, factor availability and price, and other prevailing economic conditions).

Figure 3.3: Technological choice process

Source: Stewarts (1982)

3.2.3 Appropriate Technology

The concept of technology choice finds meaning in the idea that some technologies may not be appropriate, thus, the term appropriate technology, which according to Kaplinsky (2011a) evolved as a response to the pitfalls of the neoclassical framework. Its evolution has roots in the development philosophies of India's Mahatma Ghandi (Akubue, 2000). However, it was Schumacher's seminal work "Small is beautiful", published in 1973, that popularised the concept and guaranteed it a place in policy and development thinking, particularly during the 1970s and a greater part of the 1980s (Kaplinsky, 1990).

With inspiration from his progenitors, particularly Ghandi, and his professional experience as an economist advising several governments of developing countries (Willoughby, 1990; Schumacher, 2011), Schumacher recognised that production in advanced countries was largely driven by capital-intensive technologies that suited large-scale mass production. This form of production, according to him and his many sympathisers (McRobie, Jequier, Stewart, Kaplinsky, Willoughby, just to mention a few), were unsuitable for developing country economies due to factors such as low income levels, limited market size, high unemployment and limited infrastructure; hence, it was a major culprit for underdevelopment. To remedy this problem, Schumacher insisted on the development and application of what he termed intermediate technologies:

> If we define the level of technology in terms of 'equipment cost per workplace', we can call the indigenous technology of a typical developing country - symbolically speaking - a £ l -technology, while that of the developed countries could be called a £1,000-technology. … If effective help is to be brought to those who need it most, a technology [a £100- technology] is required which would range in some intermediate position between the £1-technology and the £1,000- technology. … Such an intermediate

technology would be immensely more productive than the indigenous technology (which often in a condition of decay), but would also be immensely cheaper than the sophisticated, highly capital-intensive technology of modern industry". (Schumacher, 1973 p 148)

The ideas of Schumacher resonated among academics and policy think tanks so much so that appropriate technology became a movement, but with several strands, which reflect the multiple meanings attached to the concept (Kaplinsky, 1990). A survey of the literature for this thesis reveals various definitions, indicating that the understanding of the concept depends on what technology stands for, but more importantly, on the connotation and/or denotation attached to the word "appropriate". The latter reason for the multiplicity of meanings given to the concept spins off into three main lenses of appropriateness: social, economic and environmental. The consequence is that appropriateness becomes relative and shrouded in the dynamic of the political economy of the country concerned (Kaplinsky, 1990). Thus, the critical question is: whose interest or what end defines the appropriateness of the means – technology – and the choice to be made? The subsections below present a review of a few of the definitions and highlight the basic conceptual ideas behind the three main strands.

Appropriate technology variously defined

In the United States Agency for International Development's (USAID) 1976 proposal to the US congress on appropriate technology for development in the Third World, the concept was described as:

> In terms of available resources, appropriate technologies are intensive in the use of the abundant factors, labour, economical in the use of scarce factors, capital and highly trained personnel, and intensive in the use of domestically produced inputs. In terms of small production units, appropriate technologies are small-scale but efficient, replicable in numerous units, readily operated, maintained and repaired, low-cost and accessible to low-income persons. In terms of the people who use or benefit from them, appropriate technologies seek to be compatible with local cultural and social environments. (USAID, 1976 p 11-12)

This characterisation emphasises several important objectives to which appropriate technology should serve; however, appropriateness with respect to preserving the natural environment appears missing. Contrarily, a definition by Harrison's (1980) gives some room

for the natural environment. According to him, "appropriate technology means simply any technology that makes the most economical use of a country's natural resources and its relative proportions of capital, labour and skills, and that furthers national and social goals" (1980, p 140). Wicklein and Kachmar's definition appears to be more concerned with the physical environment. They see appropriate technology as that which "... seeks to aid humans and support human ability to understand, operate and sustain technological systems to the benefits of humans while having the least negative societal impact on communities and the planet" (2001, p 4). However, they gave little attention to the employment and distributional concerns, which seem quite highlighted in USAID's definition.

Morawetz argues that appropriate technology consists of a "set of techniques which makes optimum use of available resources in a given environment. For each process and project, it is the technology which maximises social welfare if factors and products are shadow priced" (1974, p 517). Like some of the definitions already mentioned, this definition tries to incorporate the social imperativeness of an appropriate technology, however, it ignores the idea that society is usually made of different groups of varied interest and objectives. How do we aggregate these interests such that the powerless are well represented?

Jequier and Blanc's (1983) definition appears more holistic but generally follow the approach by USAID and Schumacher. According to these authors, appropriate technology is:

> … the generic term for a wide range of technologies characterised by any one or several of the following characteristics: low investment cost per workplace, low capital investment per unit of output, organisational simplicity, high adaptability to a peculiar social or environment, sparing use of natural resources, low cost of final products or high potential for employment. (Jequier and Blanc, 1983 p 10)

This definition however generally associates the term with some desirable features of technology that are favourable to a specified context. On the other hand, writers such as Willoughby (1990) and Pellegrini (1979) have adopted a more general perspective: For Willoughby, appropriate technology consists of "artefacts which have been tailored to function as relatively efficient means and to fit the psychosocial and biophysical context prevailing in a particular location and period" (1990, p 43). In Pellegrini's view, technology is appropriate "when its introduction into a community creates a self-reinforcing process internal

to the same community, which supports the growth of the local activities and the development of indigenous capabilities as decided by the community itself" (1979, p 2).

A careful examination of the various definitions including those discussed above reveals two main approaches to defining appropriate technology: specific-characteristics and general-principles definitions (Willoughby, 1990). Willoughby notes that the former assigns "specific and tangible operational criteria to the definition", based on a preconceived notion about the context in which the technology is applied and the desired ends. Thus, such definitions are normative because they are based on one's judgment about what ends are relatively more important. Examples of such definitions are those provided by Jequier and Blanc (1983), and USAID. The general-principles approach however suggests "no specific and tangible content" for technology that is appropriate but stresses the general importance of the technology being suitable for a set of circumstances. This approach therefore seeks to make the concept of appropriate technology universal and applicable to different contexts across nations and within nations. The implication is that "… there can be no unique appropriate technology to fit all circumstances. The technology which is appropriate will differ according to the nature of the country, its resources and opportunities" (Stewart and Ranis, 1990 p 4). The definitions by Harrison, Morawetz and Willoughby are examples of the general-principles definitions.

Underpinning the general-principles approach is the recognition in the literature that the use of inappropriate technologies happens in developed countries also. We can observe this in the writings of McRobie (an ardent follower of Schumacher) in his book "Small is Possible", published in 1981. He noted:

> … the first people in rich countries to discern that they too needed something on the lines of intermediate technology were those living and working in the hinterlands of large metropolitan economies… It is characteristic of such territories that they closely resemble colonies (which produce, as someone put it what they do not consume and consume what they do not produce) … if they are to do more than merely survive with the aid of welfare payments, such communities need technologies appropriate to their resources and lifestyle. (McRobie, 1981 p 76)

Economic appropriateness

Economic appropriateness can be readily determined in the neoclassical framework for technology choice (Kaplinsky, 1990): A choice is economically appropriate if the chosen technique is technically efficient and yields the minimum cost of production given the relative factor prices. Due to the shortcomings of this approach, as discussed earlier, additional criteria have been suggested in the literature for economic appropriateness. These include the scale of production, income levels or size of markets and how productive units are organised, particularly in the context of developing countries (Stewarts, 1982; Kaplinsky, 1990; Bhala, 1981).

Following Schumacher, the above authors argue that most production techniques developed in advanced countries are relatively large in relation to developing countries' market size. In many developing countries, much of production is at a relatively low scale and operated by family owned enterprises with little division of labour and specialisation. In developed countries, however, production has gone through several phases of development with current production techniques having a high degree of division of labour, specialisation and capital intensity. Techniques developed to suit a particular type of organisation, say family owned enterprise in developing countries, may be incompatible with organisational forms in advanced countries and vice versa. It is therefore argued that because of the small size of markets in developing countries, the use of techniques from advanced countries lead to excess capacity and tends to promote monopolies with limited employment potential.

Social appropriateness

The main argument here is that a technology should not conflict with the social objectives of the nation or community it is meant for but rather promote it. This was one of the major concerns of the USAID 1976 report to the US Congress on appropriate technology mentioned earlier. The idea of social appropriateness as enshrined in the USAID report has been expanded to incorporate social life in a more comprehensive manner, as captured by

Reddy (1979) (cited in Kaplinsky, 1990). According to Reddy, a technique is socially appropriate if it satisfies the following criteria:

- A preference for technologies which will enhance the quality of life, rather than merely lead to an increase in the consumption of goods.

- A preference for production technologies, which demands creative work that satisfies, rather than boring routine labour.

- A preference for production technologies in which machines are subordinated to, rather than dominate the lives of people.

- A preference for technologies based on communal, rather than individual use of goods and services.

- A preference for technologies which blend with, rather than disrupt traditional technologies and the fabric of social order.

- A preference for technologies which increase, rather than diminish the possibility and effectiveness of social participation and control.

- A preference for technologies, which facilitate the devolution of power to the people, rather than its concentration in the hands of elites.

Environmental appropriateness

An appropriate technology should have limited negative environmental externalities. That is, technologies adopted should not be those which lead to environmental degradation, but those that help conserve the gift of nature, allowing for its sustainable use. For example, using the environmental criterion, solar energy technology may be preferred to hydro-power technology in countries with tropical climates. For developing countries, environmental appropriateness of a technology is largely captured in Schumacher's words:

> The technology of mass production is inherently violent, ecologically damaging, self-defeating in terms of non-renewable resources, and stultifying for the human person. The technology of production by the masses, making use of the best of modern knowledge and experience, is conducive to decentralisation, compatible with the laws of ecology, gentle in its use of scarce resources, and designed to serve the human person instead of making him the servant of machines (Schumacher, 1973 p 127).

Schumacher makes a clear distinction between the environmental impact of large-scale production technology, which underpinned mass production in advanced countries and hardly serves the needs of the masses, and small-scale production technologies used by the masses and for the masses. As noted earlier, Schumacher referred to the latter as intermediate which, according him, "… is vastly superior to the primitive technology of bygone ages but at the same time much simpler, cheaper, and freer than the super-technology of the rich" (1973 p 127).

The environmental criterion for appropriateness is not only about mass productions, which was a major concern of Schumacher. It has been argued that technology should also reflect the climatic conditions of the country or area for which it is developed or applied (Stewarts, 1982). Stewart argues that the reason is that climatic conditions (temperature, humidity, and season) vary significantly across places, resulting in differences in natural vegetation and patterns of production and consumption.

Criticism of appropriate technology

The appropriate technology approach/movement met opposition from several critics, particularly Eckaus (1955) and Emmanuel (1982). Eckaus's challenge was that the idea about the existence of a set of efficient techniques from which an appropriate choice could be made was a mirage. Instead, at any point in time, there is only one efficient technique, which is usually capital intensive mainly because global division of labour in R&D has been extremely skewed towards advanced countries where the technologies were produced. Emmanuel corroborated Eckaus's assertion and further indicated that the efficient techniques are predominantly available to multinational companies. Coincidentally, the success of appropriate technology as a development strategy has been limited: Its influence started dwindling from the mid-1980s, with the above shortcoming being cited as one of the reasons for its failure (Kaplinsky, 1990).

However, several empirical studies have provided evidence contrary to Echaus's assertion. For example, Cooper *et al.* (1981a) studied production technologies for can making in Kenya,

Tanzania and Thailand and found that more than one efficient technique existed for producing cans in these countries, some of which were relatively old and labour intensive techniques. Similarly, with data on block making techniques in Kenya, Stewart (1982) also demonstrated the existence of more than one efficient technique. By comparing old machines (most of which were second hand) with new machines used in the UK's textile industry, Pack (1981) also showed that the old machines offer efficient labour-intensive alternatives. Consequently, Kaplinsky (2009) argues that the much more likely reason for the failure of appropriate technology strategy was its reliance on Mode I innovation paradigm[11] rather those found in Eckaus's assertion. Mode I is used to connote an innovation system that specifies a linear relationship between science, invention and innovation, with these activities mainly carried out in universities, and research and technology organisations (RTOs) (Gibbons *et. al.*, 1994). Kaplinsky (2011b) further makes the allusion that the negative effect of this innovation paradigm was to make appropriate technology unattractive to profit seeking organisations, with its diffusion mainly occurring through acts of charity rather than the market.

Largely based on mode I type of innovation, the appropriate technology (AT) movement, however, unintendedly contributed to unravelling the problem in the neoclassical analysis of technical progress. This contribution is embedded in the argument of the AT proponents that the demand and consumption patterns in advanced economies had led to the development of large-scale production technologies. The neo classicists however view technology as *manna* from heaven and technical change as a function of processes that are exogenous to the production/economic system. Also worth mentioning in respect of other significant contributions to the above recognition is the seminal work by Singer *et al.* (1969), an influential policy document that was named *The Sussex Manifesto.* Also based on Mode I innovation, the manifesto came to challenge the then widely accepted trend, where research

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[11]Mode I innovation is contrasted with Mode II (a newer paradigm), of which innovation, in simple terms, is thought to result from the interactions or nonlinear relationship between actors and processes in the generation and application of knowledge (Gibbons *et al.*, 1994). Mode II emphasises user-producer interactions especially the role of users in the innovation process (Pavitt, 1984; Kaplinsky, 2009). In relation to this, von Hippel in his book "Demcratising Innovation" places much emphasis on users' and consumers' ability to innovate and the supremacy of such innovations: "Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents" (von Hippel, 2005 p 1).

for technological innovations were mainly conducted in advanced countries and were grossly transferred to developing countries (Ely and Bell, 2009). Hence, it recognised the importance of technology to be developed from within the social, economic and political environment of its users, inadvertently suggesting that technical progress should be viewed as resulting from endogenous processes. Section 3.3 discusses the sources of technical change and the theory of induced innovation, which provide further rationale for technical change being endogenous.

3.2.4 Inclusive Innovation

Much in the spirit behind the development of appropriate technology concept, a new concept called "inclusive innovation" has emerged. Innovation is described as any useful new means or end that could be technological or non-technological. The non-technological aspect of innovation represents one way by which inclusive innovation departs from appropriate technology concept, which just focuses on technology. This new concept largely emerged after 2011 although it has been implicitly given attention in academia for a number of years (Heeks *et al.*, 2013). Terminologies such as "below the radar innovations" which can be found in the work by Kaplinsky *et al.* (2009), "grassroot innovation", written about by Verma *et al.* (2004), Seyfang and Smith (2007) and "frugal innovation" have also existed, attempting to describe almost the same idea (Heeks *et al.* 2013).

Although it is new and relatively amorphous, several authors such as George *et al.* (2012) Chataway *et al.* (2013), Foster and Heeks (2014), Heeks *et al.* (2013) and Kaplinsky (2013) have attempted to delineate inclusive innovation as a development concept. In Kaplinsky's words:

> Inclusive innovations may be new to the sector, new to a country or new to the world and may involve a variety of excluded populations. These innovations may foster inclusion in production, in consumption, in the innovation process itself and by promoting the agency of the excluded. They may also contribute to environmental and social sustainability. (Kaplinsky, 2013)

The basic element of inclusive innovation that can be gleaned from the above definition and also emphasised in other studies mentioned above is that innovation should provide the

excluded with access to consumption and production of goods and services. Similarly, Cozzens and Sutz (2012) argue that an innovation is inclusive if the process of achieving it, and the problems it is intended to address and the solutions are inclusive.

It is believed that inclusive innovation as a development strategy provides a way by which the unhealthy co-existence of high economic growth and growing poverty levels that has occurred globally over the last two decades could be addressed (Chataway *et. al.*, 2013).

3.3 Sources of technical change

An understanding of the sources of technical change can help rationalise the existence of inappropriate technologies (and innovations that are not inclusive) and emphasise the need for choices which favour technologies that are inclusive or appropriate. Attempts in the literature to understand these sources have led to the development of concepts (or theories) such as induced innovation/technical change and path dependence.

3.3.1 Induced technical change and biases in technical change

Induced technical change as a theory holds that market demand plays a key role in the advancement of technical knowledge, thus, demand is a major driving force behind technical change. This argument proceeds as follows:

> …demand for technical change in the form of product and process innovations is derived from the demand for commodities; the demand for inventive activities including research and development is derived from the demand for technical change; and the demand for advances in scientific knowledge is in turn derived from the demand for inventive activities. (Thirtle and Ruttan, 1987 p 8)

The above view challenges the initial belief that supply factors in the form of activities originating from basic science, which generate scientific knowledge determine advances in technology and in a linear fashion – the mode I type of innovation process. This belief in the supply factors is based on the assumption that the market is able to passively absorb all the innovations or technical change (Crespi, 2004). Other studies, however, emphasise the important role of both demand and supply and their interactions, highlighting a nonlinear relationship between science, invention, innovation and production (Nowery and Rosenberg,

1979; Walsh, 1984; Kline and Rosenberg, 1986; Popp, 2002; von Hippel, 1994, 2005). The emphasis on the nonlinearity can be seen in Kline and Rosenberg's words:

> Models that depict innovation as a smooth, well-behaved linear process badly misspecify the nature and direction of the causal factors at work. Innovation is complex, uncertain, somewhat disorderly, and subject to changes of many sorts. … The process of innovation must be viewed as a series of changes in a complete system not only of hardware, but also of market environment, production facilities and knowledge, and social context of the innovation organisation. (Kline and Rosenberg, 1986 p 275)

The nonlinearity and the importance of demand factors stress the fact that rather than technology being a given, changes in the economic environment matter for advances in technology, hence, technology is not like manna from heaven, contradicting the neo classicists' and early growth theorists' conceptualisation. Based on a review of the work of many writers, including empirical studies (such as Hicks, 1932; Griliches, 1957; Schmookler, 1962, 1966; and Vernon, 1979), Ruttan shows that market demand is an important factor determining the supply of knowledge and technology although supply factors can never be ignored.

In the search for empirical evidence to support the hypothesis that the demand factors are important, Schmookler (1966) analysed the relationship between patented capital goods invention and investment in the US and found a significant positive association. Scherer (1982) revisited Schmookler's analysis with improved data and confirmed the relationship although he found a relatively less strong association. Geroski and Waters (1995) also found innovative activities at the macro level tend to be pro-cyclical and that variations in economic activity (in other words, aggregate demand) granger cause innovations. Accordingly, Kaplinsky (2011a) suggests that demand factors make less surprising the observation that high income markets tend to stimulate technical change in favour of quality and differentiation while in low income markets consumers would usually want to trade quality and differentiation for lower prices.

In addition to demand, factor prices and several other economic factors are also important in the theory of induced technical change. As Binswanger has indicated, models of induced

technical change represent "… an attempt to discover the roles played by factor prices, goods prices, and other economic variables in determining the rate and direction of technical change" (1978 p 13). The direction of technical change indicates whether the new technologies favour the production of certain goods and services, as Kaplinsky (2011a) argues, and/or exhibit biases in the use of the factors of productions. For the latter case, technical change is said to be bias if new technologies (techniques) in comparison with the old techniques tend to economise on the use of a factor of production relative to the other factors.

Figure 3.4, which is based on the same assumptions underpinning Figure 3.1, illustrates the concept of factor biased technical change. It should be noted however that all the four isoquants in Figure 3.4 represent the same level of a homogenous output, that is, output is fixed and hence the different isoquants respectively represent different states of technological knowledge where I_1, I_2 and I_3 are new technologies superior to I_0. Moreover, factor prices are constant, hence, the movement from isocost PP to P'P' represents resource savings rather than being the results of increases in the factor prices by similar proportions. The initial equilibrium before any technical change occurs is at point A. If a new technology results in a new equilibrium at point B on isoquant I_1, then technical change brings about equal proportionate savings in both factors. Note that the capital-labour ratio, represented by the slope of the line $0k_0$, is the same for the two equilibria. This condition is referred to as the neutrality of technical change, of which the above specific form[12] is attributed to Hicks (1932), as indicated by many writers such as Thirtle and Ruttan (1987) and Barro and Sala-i-Martin (1995).

Bias in technical change is defined with reference to the neutrality scenario. For example, if the new equilibrium occurs at point C, then technical change is labour saving while it is capital saving if the new equilibrium is at point D. The capital-labour ratio at point C, measured by the slope of the line $0k_1$, is higher than that at point B, suggesting that the

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[12] Other types of neutrality of technical change are also found in the literature. These include Harold neutrality and Solow neutrality. Readers interested in these other forms should see Barro and Sala-i-Martin (1995). For the present purpose, which is to illustrate the existence of biases, the discussion on Hicks neutrality suffices.

technical change led to a reduction in the amount of labour units required for producing the output. Conversely, the capital-labour ratio at point D will be lower than at point B, indicating that the new technology is capital saving.

Figure 3.4: Neutrality and bias of technical change with constant factor prices
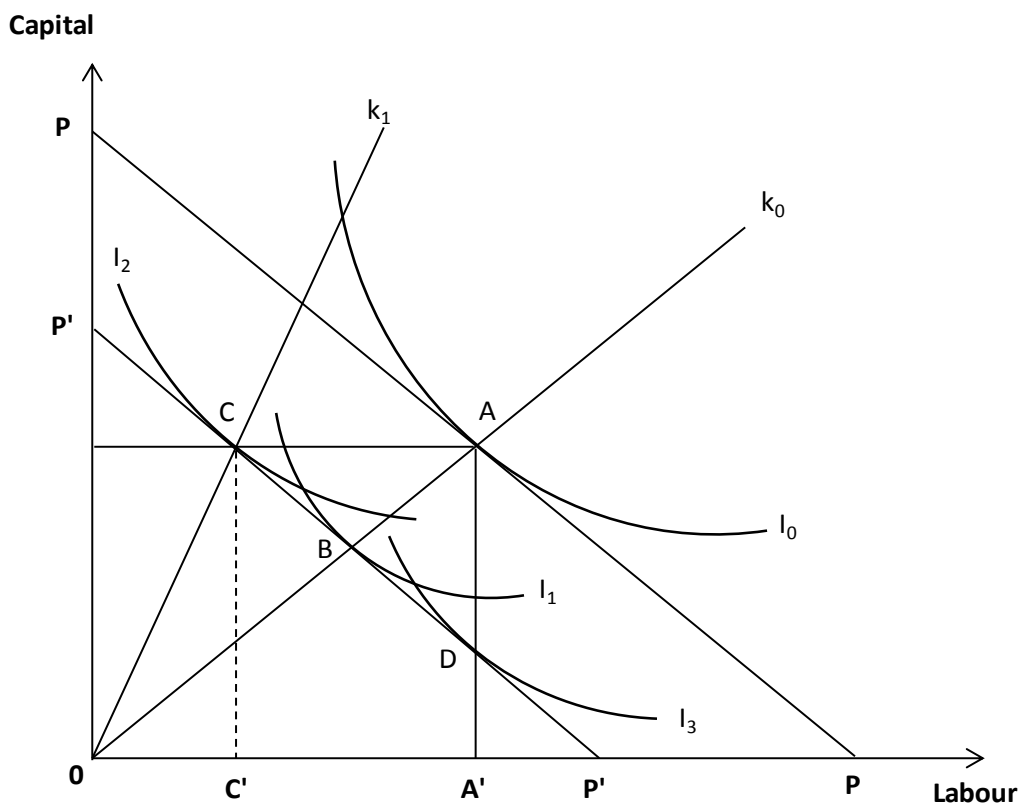
Source: Thirtle and Ruttan (1987)

The implication of biases in technical change for income distribution and employment is obvious. For example, technical change that is labour saving increases unemployment while redistributing income from labour to owners of capital. Bias in technical change in itself can also produce changes in relative factor price in favour of the factor that received the positive bias of the technical change by increasing the demand for that factor, further worsening the income redistribution effect (Acemoglu, 2001, 2002; Krugman, 2012a, 2012b). Krugman (2012a) shows that the increasing use of robots in production in recent years has shifted income away from labour to capital in the US.

Interestingly, and as alluded to earlier, an important aspect of the theory of induced technical change is the emphasis placed on the impact of changes in factor prices. Academic interest

in the effect of factor prices on technical change began with Hicks (1932), who indicated that "A change in relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind – directed to economising the use of a factor which has become relatively expensive" (p 124-5, cited in Acemoglu (2002 p 784)). Fellner (1961) and Kennedy (1964) theoretically formalised Hicks' ideas. The implication of this theory is that factor endowments, which determine movements in relative factor price, can be responsible for the direction or bias in technical change (Ruttan, 2001). In other words, if a particular factor of production (say, labour) has become or is expected to become relatively more expensive or scarce, then this will lead to labour-saving technical change, as shown in the empirical example by Acemoglu and Finkkelstein (2008) mentioned earlier in Section 3.2.1.

Many other studies also provide empirical tests for technical change that results from changes in relative factor prices. Examples are Hayami and Ruttan (1970), Binswanger (1974), Cain and Paterson (1986), Kawagoe *et al.* (1986), Clark and Youngblood (1992), Lambert and Shonkwiler (1995), and Liu and Shumway (2003). Mainly relying on time series data, most of these studies have found the data to be highly consistent with induced technical change. Using 1880-1960 aggregate data from US and Japan, Hayami and Ruttan (ibid) regressed the log of factor ratios on the log of factor price ratio and provided strong evidence for the existence of induced technical change. Similarly, Cain and Paterson (ibid) found the presence of biased technical change in US manufacturing data which occurred as a response to factor price movements. Liu and Shumway (ibid) also found evidence for induced technical change at the regional level but not at the national level using time series data from the US. Contrarily, Clark and Youngblood's (ibid) study found little evidence for induced technical change for central Canadian agriculture using time series data, concluding that technical change had been neutral.

However, it should be noted that changes in relative factor prices can result in two effects: factor substitution and technical change which may be neutral or biased. According to Thirtle and Ruttan (1987), Hicks's (1932) definition of induced innovation sought to distinguish factor substitution from technical change; however, confusion about the theory of induced technical

change is as a result of the fact that it is conceptually difficult to untangle the two effects of changes in relative factor prices. Thirtle and Ruttan (ibid) argue that the confusion stems from the fact the theoretical distinction between factor substitution that occurs along a given isoquant and technical progress represented by a shift in the isoquant is "… a poor description of a more complex reality …" (1987, p 20). Nelson (1980) suggests that the distinction presupposes the idea that learning and doing are two different activities, which does not reflect reality because technical change at the firm level may require investment in research and development and learning-by-doing. This problem reflects the empirical difficulties in estimating factor-price induced technical changes as discussed in Oniki (2000).

The literature also indicates several other economic factors which underpin induced innovation process. Acemoglu (2001, 2002; 2007) analyses the effect of market size on biases in technical change. He draws a distinction between market size effect and price effect: The latter encourages innovations directed at scarce factors; however, the former leads to technical change that favours abundant factors. Acemoglu's analyses suggest that the relative strength of these two effects depends on the elasticity of substitution between the factors, indicating that "When the elasticity of substitution is low, scarce factors command much higher price and the price effect is relatively more powerful" (Acemoglu, 2002 p 783). On the other hand, a sufficiently large elasticity of substitution can produce induced bias in technical change towards the factor that has become more abundant, finally leading to an increase in the reward to that factor. He used this result to explain why there was an increasing wage premium for college graduates in the post-war US economy although the relative supply of skills in the US increased rapidly over the same period.

3.3.2 Path dependence

Kaplinsky (2011a) treats path dependence as another reason for induced technical change, though Ruttan (2001) treats it as an independent source of technical change in general. From whichever perspective, the main import is that technical change may be path-dependent, that is, the nature of existing technologies (in use) determines the direction or

features of the next generation of technologies. As explained in Ruttan (ibid), this happens as a result of the limited reversibility of investment, economies of scale associated with highly accepted innovations and the fact that technical change may have to produce outcomes that are compatible with existing systems.

These factors leading to path dependence can cause inefficient technologies to be introduced and become successful or lock-in. Studies by David (1985, 1986; 1997) on the typewriter keyboard provides an example of how an inefficient technology (QWERTY typewriter keyboard technology in his studies) can be developed and become widely adopted, as a result of the factors influencing path dependence. By similar logic, path dependence can explain the existence of inappropriate technologies (Kaplinsky, 2011a). This issue becomes crucial if technologies developed in one place, say advanced countries, are being transferred to and applied in other contexts, say developing countries.

3.4 Determinants of technology choice/ adoption

Daniels and Robles (1992) argue that technology choice occurs in a multivariate setting where many factors at the country and industry level as well as product and innovation specific variables are important and this viewpoint is supported by the discussions presented in this chapter thus far. As was noted earlier, the neoclassical model of technology choice places emphasis on relative factor price (and/ or factor endowment) and the extent of factor substitutability. Stewart's framework for technology choice discussed in Section 3.2.2 highlighted other important factors such as the heterogeneous nature of firms and scale factors. In this section, the determinants of a firm's technology choice are further discussed with the aim of providing more details on how firm characteristics and other factors such as macro and meso policies or regulatory environment may affect a firm's decision to adopt a technology. The characteristics of the technology, which are also important determinants of choice, are not given attention in this subsection since those factors featured prominently in the discussions in all the preceding sections in this chapter.

3.4.1 Firms' characteristics and target market

In reality, firms are not homogenous but may differ in many ways. They may differ with respect to their objectives, size, knowledge about available technologies, resources available to the firm, which include material inputs, labour of various skills, and capital equipment (Stewart, 1982, 1987; and Stewart and Ranis, 1990). For example, a government-owned corporation may have other aims apart from profit maximisation (e.g. employment expansion) compared to a locally owned public enterprise, and this may have implications for technology choice (Stewart, 1982). Thus, the characteristics of firms may influence technology choice since firms are not homogenous in reality.

Many other studies including empirical work point to the fact that firms' heterogeneity has important implications for technology choice. Using empirical data on looms for cotton textile weaving in Korea, Rhee and Westphal (1977) found evidence that firm characteristics (such as size, ownership and location) have implications for the choice between semi-automatic and automatic loom technologies and between domestic looms and imported looms. A recent empirical study by Bertschek *et al.* (2013) on German firms also confirms that firms' heterogeneity can lead to different technology choice. Brandt and Zhu (2005) used survey data on 250 firms in Shanghai and found that a firm's attributes such as age, size and human capital influence its technical capacity, which in turn affects the firm's decision to adopt a technology or not. Brandt and Zhu's study further shows that among firms with the same technical capacity, the ones with better access to cheap bank credit are more likely to embark on larger technology projects and invest more in imported equipment from technologically advanced countries. Similarly, with an empirical analysis based on data from five Latin American countries, Hasan and Sheldon (2013) confirm that firms face credit constraints in technology adoption.

Negri and Brooks (1990) examined the determinants of farmers' choice between two irrigation technologies with a national cross sectional data on farms in the US by relating the probability of choosing the technologies to the physical and economic attributes of the farms.

They found that size had a significant and differing impact on the selection of the two irrigation technologies, although soil characteristics of the farm appear to dwarf the impact of all other factors for the two technologies including size. Moreno and Sunding (2005) examined how a farm characteristics and technology characteristics affect the adoption of irrigation technology in a nested logit model, using data from Kern County in California. Their results indicated that farm characteristics affect technology choice. Although these studies were on farms rather than manufacturing firms, they show that the characteristics of the unit for which the technology choice is made influence the choice outcome or that the characteristics of the unit making the choice influence the outcome.

Much earlier studies on technology adoption (such as Ryan and Cross, 1950; Griliches, 1957; and Mansfield, 1961) showed that the extent of contact between users and potential adopters of a technology has a major influence on the potential adopters' choice in favour of that technology. While these earlier studies' main focus was to explore the rate of diffusion of innovations, the factors they identified to influence diffusion inherently underpins technology choice or adoption (at the micro level) by firms. Other studies on diffusion such as Salter (1960), Davies (1979) and Karshenas and Stoneman, (1993) have also emphasised the importance of firm heterogeneity particularly with respect to factors such as the firms' age, size, capital vintage, corporate status and R&D expenditure. It has also been recognised that firms may also differ in terms of their access to a fixed critical input needed for a technology (Ireland and Stoneman, 1985; Fundenberg and Tirole, 1985). Moreover, strategic interactions between firms are also important for adoption behaviour (Reinganum, 1981; Quirmbach, 1986).

Many other studies have also emphasised the importance of a firm's size as a determinant of technology choice. Hannan and McDowell (1984) studied factors which influence banks' adoption of ATM technology and found that larger banks had a higher probability of adopting ATM technology, all things being equal. Dorfman (1987) suggested that firm size plays a key and positive role in the level of innovative activities of firms, an argument that Hall and Khan (2003) believe is applicable to the adoption of a new technology.

The discussion thus far shows that firms' size, which is related to scale and the degree of the firm's market power, is important for technology choice or adoption. Reasons given in the literature include: (1) large size allows for appropriating the benefits of scale economies given that the new technologies may be scale-enhancing (Hannan and McDowell, 1984; Dofman, 1987), (2) the possible differences in managerial attitudes and risk exposure for firms of different sizes (Hannan and McDowell, 1984). However, Hall and Khan (2003) note that large size and market power can negatively affect a firm's adoption decision because larger firms tend to have sophisticated bureaucracies that may also slow down the adoption decision.

Other factors that may affect a firm's adoption of technology include the target market of the firm, which may also be considered as an attribute of the firm. Daniels and Robles (1992) examined the relationship between export commitment of textile firms in Peru and their adoption of capital-intensive technologies. These authors found a positive relationship, for which their explanation was that exporters appear to be more concerned with product quality perceptions and reliable delivery outcomes. Stewart (1987) also argues the nature of markets (with regards to size, industry and type) that a firm faces also affect technology choice. By "type" of market, she referred to the various segment of the consuming market that a firms produces for, which could be high-income or low-income market on one hand and local or international markets on the other hand. She however noted "… the market is also a variable that can be changed by the activities of the firms" (Stewart, 1987 p 6).

Relatedly, a study by Hall and Khan (2003) suggests that a secure customer base for a firm may positively affect its technology adoption decisions. Similarly, in a study on the adoption of CNC machines by firms in the auto component supply industry in the US, Helper (1995) found that a firm's relationship with customers (a form of guarantee for future demand) influences the firms' choice in favour of the CNC machines.

3.4.2 Government policy/regulation and macroeconomic conditions

The external environment of a firm influences its technology choice although the actual decision usually takes place at micro level (i.e. by the firms) (Stewart, 1987). Government may directly intervene in particular investment decisions on technology as well as indirectly influence the technology choice of micro units (or firms) by using macro and meso policies to alter the external environment within which the firm operates (Stewart, 1987; Stewart and Ranis, 1990).

According to Stewart (1987), the macro-policies that may affect firms' technology choice range from those that are geared towards major economic aggregates such as money supply and credit creation, interest rates, budget deficits and trade protection to policies that influence technology supply and market access. Meso policies are however concerned with the distributional and sectorial implications of macro policies and are also used as a tool to influence technology choice (Stewart and Ranis, 1990). Based on the results from many empirical studies, Stewart and Ranis (1990) show how macro and meso policies indirectly affect firms' technology choice through their impact on the firms' objectives, resource availability and cost, markets in which they operate, and technology availability. For example, government policies to increase interest rate will lead to an increase in the cost of borrowing to finance machine acquisition while government-subsidised credit facility for investment in farm machinery, for example, may encourage farmers to invests more in mechanisation techniques.

Other empirical studies that have found a significant influence of the regulatory environment on technology choice or adoption include Hannan and McDowell (1984) and Gray and Shadbegian (1998). Hannan and McDowell's study shows that the regulatory environment for banks affects their decision to adopt a technology. In Gray and Shadbegian's study, they found that technology choice by firms in the US paper and pulp industry was affected by changes in environmental regulations that took place in the US between the 1970s and 1980s.

Government policy and regulations cannot be overemphasised but also important is nature of the macroeconomic environment, which is in part conditioned by government policies. For example and as noted earlier, a firm's access to finance is critical for technology choice; however, credit constraint at the micro level is also embedded or conditioned by the dynamics within the aggregate financial system, of which the neoclassical framework for technology choice pays no attention to. Interestingly, studies such as Hicks (1969) and Bencivenga *et al.* (1995) showed that the behaviour of financial markets can affect the equilibrium choice of technology. Hicks (ibid) argued that it was the financial revolution in the first half of the 18th century Britain that paved the way for the industrial revolution, which started in the second half of that century, and that the latter revolution did not happen merely due to the advent of newly discovered technologies. He observed that a highly significant part of the technical innovations associated with the industrial revolution had already existed before the start of the industrial revolution. However, they were not in use because they required large-scale illiquid capital investments, which were unattractive because well-functioning financial markets were absent. According to him, England by the 1750s had developed financial markets, which would support the adoption of technologies with high sunk cost. Bencivenga *et al* (1995) formally examined the theoretical implications of Hicks' observation in an overlapping generations model with production and shows how the cost of financial market transactions affect the set of technologies in use and the equilibrium growth rate of the economy.

Munro (1989) places much emphasis on the importance of macroeconomic conditions on technology choice. He argues that "… the whole gamut of macro economic structures are relevant to the choice of techniques" (1989 p 22). His study on Bhutan found that macroeconomic and environmental conditions of Bhutan have important implications for technology choice and that labour intensive technologies generally deemed appropriate for developing country were inappropriate in the context of Bhutan.

3.5 Technology transfer/diffusion

Largely, technology transfer and technology diffusion have been used interchangeably in the literature and definitions of technology transfer often embody the term "diffusion" (Ramanathan, undated). For example, Grosse (1996) defines technology transfer as the diffusion of a technology from the place of its introduction to another. Eneh (2010) however shows a subtle but an important difference between the two concepts. He refers to technology diffusion as the spread of technology for general use and application within a given social system while technology transfer involves specific and intended processes occurring between the transferor and the transferee. Along similar lines, Nichols (undated) argues that technology transfer involves communication between a specific donor and a specific recipient or group of recipients while in the case of diffusion the donor may not be aware of whom the recipient may be. Hameri (1996) and Ramanathan (undated) have sharpened the distinction: transfer involves a proactive process and presupposes agreements unlike diffusion, which occurs in a passive manner.

Both transfer and diffusion concepts may also assume an international character when technology is transferred or diffused beyond national borders. For example, Papaconstantinou *et al* (1996) in their attempt to study the diffusion process of embodied technology in selected OECD countries distinguish between diffusion across industries and that across countries. Similarly, Teece (1977) classified technology transfer into domestic and international types.

3.5.1 Technology transfer types and the mechanisms of transfer

Having emerged in the late 1960s, this subject has received much attention especially in academic circles; hence, the literature on the subject is vast and varied (Contractor and Sagafi-Nejad, 1981). Technology transfer can either be vertical or horizontal, as discussed in Mansfield (1975) and Grosse (1996). Souder (1987) refers to the former as internal technology transfer and the latter as external technology transfer.

Vertical technology transfer occurs when knowledge from basic science is used in applied research and that from applied research results in product development and finally production (Mansfield, 1975). Mansfield further notes that the transmission of information from basic science through production may not be linear and unidirectional, thus, information may also flow in the reverse order. Amsden (1989) and Habibie (1990) provide additional insight by indicating that in the context of developing countries, vertical technology transfer start or should start from production and move backward to research. Moreover, the nature of the information may be changing as it moves along each dimension or across each unit within the transfer process (Mansfield, 1975). The process by which the famous US hybrid corn technology[13] was developed and applied for commercial maize production encapsulates the idea of vertical technology transfer. The hybrid corn was developed in the laboratory of the Iowa State Agricultural Experiment Station in 1928 and was later adopted by the majority of corn growers in Iowa. Another but more recent example is how the study of genetics has led to the introduction of genetically modified food crops.

Horizontal technology transfer, on the other hand, involves transferring a technology used in a place, organisation or context for use in another place, organisation or context (Mansfield, 1975). The type of technology transfer which occurs when multinational corporations set up subsidiaries in foreign countries is a specific form of horizontal technology transfer. A study by Noisi and Zhegu (2010) provides a good example of this type of technology transfer within the commercial aircraft manufacturing industry. They showed that commercial aircraft manufacturing technologies from their places of origin (Western Europe and North America) have been transferred to newly industrialising countries such as Brazil, Russia, India and China (BRICs). They further noted that these new entrants into the aircraft manufacturing industries are doing so well that the North American and Western European industries risk losing their dominance to their developing countries' counterparts.

Both vertical and horizontal transfers incite much inquiry. However, by following the objectives of this study, the rest of this subsection focuses on horizontal transfer of

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[13] Details on the hybrid corn technology are provided in Ruttan (2001) and Ryan and Cross (1943)

technology. Analysing mainly from the perspective of firms, particularly multinational companies (MNCs), a strand of the literature on horizontal technology transfer has focused on the transfer process and the effectiveness of the transfer. Examples are the work by Al-Ghailani and Moor (1995), Djeflat (1988), Godkin (1988), Kumar (1995), Dahlman and Westphal (1981), Mockler (1995), just to mention a few. Another set of the literature has however concentrated on the mode (or mechanism) of the transfer and factors determining the choice of a particular transfer mode. This thesis focuses on the latter set of the literature, of which the survey for this thesis shows that the mode of technology transfer can take several forms, depending on the governance structure between the transferor and the transferee (Contractor and Sagafi-Nejad, 1981; Grosse, 1996; Steenhuis and de Bruijn, 2005; Chen, 2005). Generally, the transfer can take place through arm's length market/trade, direct investment and more generally through the network forms between firms, which may be global in the case of international technology transfer.

Arm's length market

Arm's length market as a mode of transfer involves a firm selling a product, process or skill to another (Grosse, 1996). For transfer across international borders, the arm's length arrangement involves importation or more generally trade. Many studies therefore consider trade as a mode of technology transfer (examples include Saggi, 2002; Das, 2000; Groizard, 2002; Mayanja 2003; Le, 2008; de la Tour *et al.,* 2011), which is generally synonymous with the arm's length market mode.

Trade in both consumption and capital goods can serve as a means of technology transfer because domestic firms get the opportunity to absorb technological knowledge embodied in the imported goods (Saggi, 2004; Hoekman *et al.*, 2004). The literature however shows that trade in capital goods that are used for the manufacture of consumer and intermediate goods produce higher benefits than trade in consumption goods (Saggi, 2004; Xu and Wang, 1999). Kim (1991) showed that capital goods importation served as a major channel for technology transfer from Japan, the US and other advanced economies to Korea between the 1960s

and 1980s, with the imports from these sources increasing significantly throughout that period. A more recent study by Munemo (2013) also provides empirical evidence supporting the idea that trade in capital goods serves as a significant technology transfer channel. Using trade flow data from UN COMTRADE, the author found that increases in SSA countries' importation of capital goods from China enhances economic growth in Africa, advocating for trade liberalisation policies that attract Chinese capital goods on a non-preferential basis. By examining trends in capital goods importation from China to other developing countries, a report by UNCTAD (2012) has also emphasised the importance of technology transfer element of this trade flow.

For other forms of technology (aside from equipment and machinery or artefacts), that is, technology items such as process techniques, patents, trade secret and industrial designs, the transfer usually involves **licensing** agreements between the buyer and the seller of the technology item. Chen (2005) however suggests that even where licensing is used, it is not the only market arrangement through which the technology can be transferred but represents only one option under market based governance structures underpinning technology transfer. He argues that the transferor or technology developer and the recipient (or transferee) may have complementary capabilities in the sense that marketing the final product (manufactured by the transferee) may provide opportunity for the transferor to also market its technology as if it were a separate product. In this way, the two parties can carry out *co-marketing* to customers and at the same time establish an arm's length relationship between them.

Though not emphasised by Chen, an important concept underpinning co-marketing relationships is *modularity* – a characterisation for a functional unit of an embodied technology that is capable of maintaining its intrinsic properties with no regard to what is connected to (Noisi and Zhegu, 2010). Modularity therefore allows a component of a product to be produced by a firm other than the producer of the final product.

An alternative to co-marketing pointed out by Chen (2005) is for the firms to engage in *contractual manufacture,* where the transferor buys back the output of the transferee in a market transaction without any resort to licensing contracts. According to Chen, "Unless all these market arrangements have failed simultaneously, it is unnecessary to internalise technology development and product manufacture within the same hierarchical establishment through direct investment" (2005 p 232).

Direct investment

In addition to arm's length market arrangement, internalisation theory of the firm with its focus on transaction cost analysis suggests that technology transfer can take place within a firm through direct investment (including foreign direct investment in the case of international technology transfer) where the transferor establishes a subsidiary. Many studies such as Contractor (1984), Anderson and Gatignon (1986), Gatignon and Anderson (1988), Chen *et al.* (2001), Rugman and Verbeke (2003) and Niosi and Zhegu (2010) have emphasised direct investment as an important entry mode for firms seeking opportunities in foreign markets and at the same time transferring technologies to those markets.

Network modes and GVC governance structures

The arm's length market/trade and direct investment were the modes initially emphasised in the literature. For example, Contractor's (1984) examination of the factors influencing mode of transfer only focused on the choice between licensing (an example of arm's length trade) and direct investment. A major difference between these two modes relates to the degree of control exercised by the transferor over the transferee. At one extreme of the spectrum (of control) is licensing, which involves very little or no control, and at the other extreme is direct investment, representing absolute control. In other words, the governance structure between the transferor and transferee is what delineates the different modes of transfer (Saliola and Zanfei, 2007). Between these extremes are hybrid forms of governance relationship, defining other modes of transfer such as joint venture and crossing licensing (Anderson and Gatignon, 1986; Hernnat; 1988; Chen; 2005; Eneh, 2010).

The role of the governance structure between the transferor and transferee in defining the different modes of transfer has been emphasised in the global value chain (GVC) framework. A GVC is a value chain[14] whose various links are fragmented over different parts of the world. Gereffi *et al.* (2005) identifies five GVC governance types – hierarchy, captive, relational, modular and market. These different structures reflect the varying degrees of "explicit coordination" and "power asymmetry" between the firms that are participating in the different links and sub links within the chains. Characterised by a high degree of explicit coordination and power asymmetry, hierarchy structures involve vertical integration through direct investment, thus, hierarchy is synonymous direct investment channel discussed earlier. For captive structures, suppliers in the chain become dependent on lead firms, who monitor and control their activities while a relational structure is usually characterised by a high degree of mutual dependence and asset specificity. In the case of modular structures, the suppliers in the chain make products to customer's specification, taking responsibility for technology usage and investment. The market structure involves arm's length relationship, as described earlier, with very low explicit coordination and power asymmetry. Though it is arm's length, Gereffi *et al.* (2005) indicate that repeat purchases are not ruled out.

After the seminal work of Gereffi *et al.*, more recent studies (e.g. Palit, 2006; Saliola and Zanfei, 2007; Brach and Kappel; 2009; Pietrobelli and Rabellotti, 2011) have specifically attempted to understand international technology transfer mechanism using the governance structure in GVC framework, as outlined above. Saliola and Zanfei (2007) suggest that all the types of governance structures correspond with different modes by which international technology transfer can occur. Brach and Kappel (2009) show that long term contracts and subcontracting within global value chains have emerged as important forms of transnational cooperation, hence, as important channels for technology transfer. They indicate that for non-OECD countries these channels are critically important since such countries attract

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[14]Kaplinsky and Morris describe a value chain as "…the full range of activities which are required to bring a product or service from conception, through the different phases of production (involving a combination of physical transformation and the input of various producer services), delivery to final consumers, and final disposal after use" (2001 p 4). Production for example forms a link within the chain and each link within the chain may also have sub-links.

limited amount of foreign direct investment and undertake little to no original research and development. Pietrobelli and Rabellotti (2011) corroborate this observation by noting that participating in GVC is important for small firms, operating in developing countries because it provides "…crucial means of obtaining information on the type and quality of products and technologies required by global markets and of gaining access to those markets" (2011, p 1262). In Niosi and Zhegu's (2010) study, they provide empirical evidence on GVCs as a major channel for the transfer of commercial aircraft manufacturing technology from North America and Western Europe to the BRICs.

Other modes of transfer

In addition to the modes already discussed, other modes of transfer can be identified in the literature. These include migration, franchising, turnkey projects, technical consultancy and official development assistance between nations (Jafarieth, 2001; and Buckley, 1985; Kim, 1991). Thus, a thorough survey of the literature reveals many different modes of transfer, which are partly due to the existence of a variety of technology forms, as discussed earlier in Section 3.1. For specific forms of technology, therefore, some of the modes discussed may not apply. Unsurprisingly, Maskus (2004) suggests that the bulk of technology transfer mainly occurs through FDI, trade and licensing contracts.

3.5.2 Choosing a mode of technology transfer

Dating back to the work of writers such as Mansfield (1975), Teece (1977), Contractor and Sagafi-Nejad (1981) and Contractor (1984), the literature shows that the primary determinants of the choice of a transfer mode are the cost associated with the technology transfer and the degree of appropriability of the proprietary advantage associated with the technology at the destination. Rather than referring to the royalty costs or rents that must be incurred merely to gain access to the technology, Teece (1977) defined transfer cost as the cost of transmitting and absorbing all of the relevant disembodied knowledge, that may either be associated with embodied technology or may represent the entire transfer object. Appropriability involves the extent to which the transferor can maximise and extract the

returns including any likely monopoly rents (Contractor, 1984). Contractor further indicates that the corporate choice amounts to a comparison of the risk-adjusted net present values of the income stream realisable from a destination under the various modes applicable.

The transfer cost and returns are in turn determined by many factors relating to the characteristics or type of technology, the characteristics of the firms (transferor and transferee) involved, the characteristics of the industry, the characteristics of countries of both the transferor and transferee with respect to government policies, markets, and economic, political and cultural conditions in general (Caves, 1971; Davies, 1977; Contractor 1984; Davidson and McFetridge, 1985; Grosse, 1996, Teece 1977). For example, Davidson and McFetridge (1985) suggest that internal transfer mechanisms through direct investment may be preferred to arm's length market transaction if the technology being transferred is new with limited transfer history and the parties involved have little or no experience in similar transactions. With regards to GVC governance modes, Gereffi *et al.* (2005) specifically mentioned three factors – the complexity of transactions, ability to codify transactions and the capabilities in the supply base – as the determinants of the choice or the evolution of a particular governance mode.

3.6 Conclusion

The discussion in this chapter began with a review of the various meanings given to the term technology in the literature. It has been shown that technology can stand for an artefact, a technique (or a process), a form of organisation and the network between organisations.

The chapter also reviewed theories on technology choice, of which emphases were placed on the neoclassical theory and an approach from Stewart, with the discussion addressing the concept of appropriate technology. Another significant aspect of the literature review has to do with the theory of induced technical change which emphasises the need to view technical change as the outcome of endogenous processes within a given economic system, hence, biases in technical change can occur as a response to the nature of demand, factor endowments and other socioeconomic factors. Other major points that can be gleaned from

the review is that while relative factor price is an important determinants of technology choice, there are other important factors such as scale, income levels, who is making the choice, the type of product or service to be produced with the technology, infrastructure, and the nature of final (consumer) market. These factors are crucial to the extent that they can lead to the selection of inappropriate technologies although efficient and appropriate ones may exist. Such choices could lead to a development trajectory that is not "inclusive", as pointed out by the literature on inclusive innovation.

The review has also shown that technology transfer can occur through a multiple of channels such as arm's length trade or licensing, direct investment and the network structures that characterise value chains. The selection of a transfer mode depends on the characteristics of the technology being transferred, the characteristics of the transferor and transferee, and also the socio-economic and political conditions in the transferor's and the transferee's environment (nations in case of international technology transfer).

It should be noted that none of the studies cited in the review specifically focused on the transfer of technologies including capital goods (machinery and equipment) from China to Sub Saharan Africa and the appropriateness of such technologies in relation to those from advanced countries. Moreover, the empirical work on appropriate technology reviewed is old, with most of the data dating back to the 1960s and 1970s. Meanwhile, a lot may have changed as a result of incremental innovations and the fact that innovations are conditioned by demand factors, which are dynamic in nature. This thesis aims to contribute to filling this gap in the literature by using recent field data from furniture manufacturing firms in Kenya.

The next chapter presents a conceptual framework guiding the empirical analyses in this thesis. Given that the term technology has various meanings, the Chapter provides an operational definition for technology as used in the empirical work for this thesis. The chapter also discusses the research approach adopted, how the data were collected, and the sampling procedure used for selecting the study participants.

CHAPTER 4 : METHODOLOGY

4.0 Introduction

This chapter discusses the conceptual framework and the research method employed for collecting and analysing the empirical data. The conceptual framework draws on ideas from the literature reviewed in Chapter 3. The research method adopted is a combination of both qualitative and quantitative approaches to data collection and analyses. The principles of pragmatism provide the philosophical anchor for the research approach adopted in this study. As a reminder, this research approach was used to find answers to the following research questions:

1. How distinctive are Chinese technologies used in Kenya furniture making industry with respect to their technical and economic/social characteristics?

2. How are the Chinese technologies transferred from China to the Kenyan firms compared to the advanced country technologies?

3. To what extent have the firms adopted the Chinese technologies, compared to those from advanced countries and Kenya and what factors influence adoption across the firms?

Due to the ambiguities surrounding the meaning of technology, as discussed in Chapter 3, this chapter first provides an operational definition for technology before presenting the conceptual framework used in this thesis, followed by the discussions on the research method, the justifications for studying furniture manufacturing in Kenya and then the challenges encountered in the data collection exercise.

4.1 Operational definition of technology

As the last chapter showed, technology can refer to many different things, making it important to provide an operational definition which helps narrow the focus of the study. In this regard, technology in this study refers to equipment or machines and the technological knowledge embodied in them. Primarily, the definition adopted is artefact based. However,

equipment or machines used in production to some extent may be associated with a specific process technique. In other words, the adoption of a process technique may require investment in specific types of equipment and vice versa.

In this study, however, I focus on the artefact aspect of technology without trying to disentangle the impacts of the types of technology (which are defined in terms of the sources of the artefacts – China, advanced countries and Kenya) on the process techniques used by the firms. This is because I do not expect that for a specific type of machines or artefacts, the different sources would lead to significant variations in the process techniques of the firms. A rationale for this is that the machines from China and Kenya are developed mainly through reverse engineering of similar machines from advanced countries. This however does not rule out possible differences in some of the technical and economic characteristics of the machines such as cost, scale and quality. Such differences may be the result of cost innovation underpinned by factors such as demand, factor endowment and technological path dependence that determine the direction of technical change as discussed in Chapter 3. I therefore start on the premise that if there are major differences in the process technology used by the firms, then that may be attributed to other factors or the differences in the level of investment in other aspects of the firms' technological capabilities and not the type (sources) of technology (artefacts) used.

4.2 Conceptual framework

By using the literature reviewed in Chapter 3 as a guide, this section presents a conceptual framework that is used to help answer the three research questions and to examine the development implications of the findings. Figure 4.1 diagrammatically depicts the framework. Indicated in the figure are the likely determinants of technology choice, the extent of penetration or diffusion (which is shown in the figure as the aggregate level of adoption) and the transfer mode. The factors influencing technology choice can be grouped into five categories: the characteristics of the decision maker (the firm); the characteristics of the

technology; the nature of final markets; government policies; and macroeconomic conditions that may affect the operations of the firms.

The diagram shows the three types of technology studied in this research (Chinese, Kenyan and advanced country technologies). Chinese and advanced country technologies are imported while that from Kenya is indigenous. An oval has been placed around the Chinese and advanced country technologies in the figure to indicate that they are imported. Advanced country technology generally referred to machines from any of the member states of the Organisation of Economic Cooperation and Development (OECD). It should be noted that while this research focuses on these three technology types, the framework could easily accommodate other types of technology, whether it is a single country or a group of countries. The Chinese technology is compared to these other two sources mainly because of the following two reasons: The first is that my preliminary field observation indicated that these sources or technology types appear to dominate Kenya's furniture making industry and the second was the need to limit the scope of the study to a manageable degree.

The figure also shows that the factors which influence technology choice can also determine the choice of a transfer mode, that is, whether a technology is transferred through arm's length market, direct investment or through the transferee's participation in the global value chain (that is, governed GVC structures) or any form of network between firms such as joint venture. Conceptually, these factors can influence the choice of a transfer mode in two main ways: They can *directly* affect the choice of a transfer mode or *indirectly* through the choice of technology. A decision maker may think about these factors in the relation to the technology options and the various transfer modes simultaneously, in which case these factors have direct impact on the choice of the transfer mode. On the other hand, another decision maker may first decide on the technology after which he/she will decide on the mode or channel to use. In this case, the technology choice mediates the factors and the choice of the transfer mode.

Figure 4.1: Conceptual framework
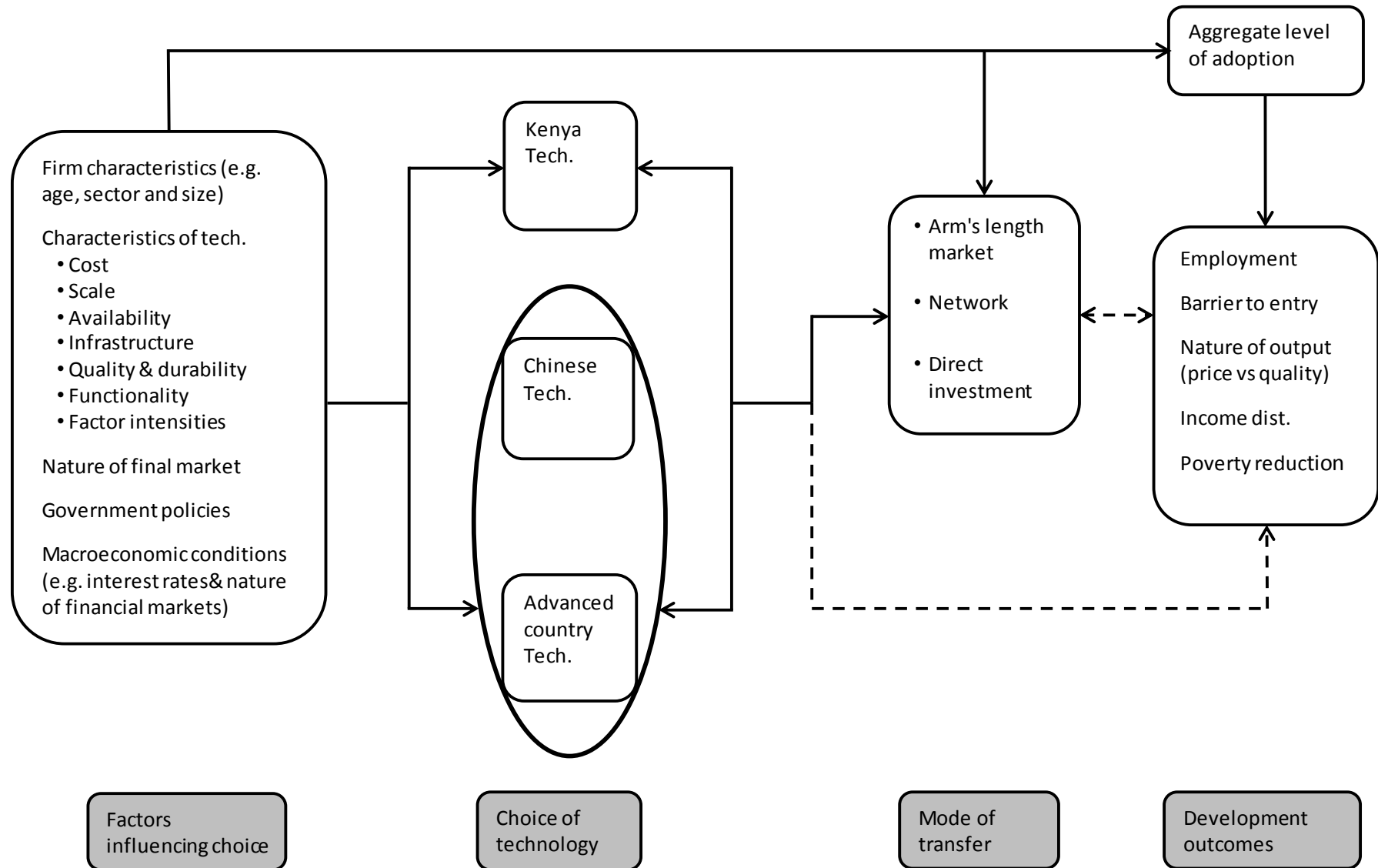
Source: Author

While the choice of technology may influence the choice of the mode of transfer, it should be noted that the availability or accessibility of a particular mode may also influence technology choice, as indicated by the two arrows pointing back to the technology choice in the diagram. Thus, there could be an endogenous relationship between technology choice and the choice of transfer mode. This is true for instances where the decision maker thinks simultaneously about the technology options and the transfer modes. The reason for the endogenous effect is that the nonexistence or inaccessibility of a transfer mode may make certain technologies unattractive for some of the firms. In the case where the decision making process is largely linear and unidirectional, the endogenous effect of the transfer mode on technology choice may not exist.

In terms of development implications, the chosen technology with its characteristics may directly influence development outcomes such as employment, income distribution and poverty reduction as indicated in the diagram. At the same time, the choice of technology may indirectly affect development outcomes through the mode of transfer used. This is because the choice of technology, as noted earlier, may determine the mode of transfer selected while each mode of transfer may independently lead to different development outcomes.

If we make allowance for choices or decision making to be carried out in more than one time horizon (i.e. inter-temporal choice process), then, the resulting development outcomes of choices, say, in the first period may affect the choices in the second period via government policies/programmes. Another likely channel for such feedback effect is the firm's social responsibility programmes if they are built into the firm's technology choice. For example, in order to create more employment a firm may choose to use labour intensive technologies particularly if such technologies are not less efficient than capital intensive ones available. This study does not intend to examine choice or decision making in more than one time horizon, and hence, the dynamic relationship between choice and the development outcomes. The reason is that the data requirement for such exercise is demanding. One

would need to collect panel data spanning at least several time horizons, an exercise limited by the time constraint on my PhD work, where fieldwork was limited to just about one year. The study therefore focuses on one time horizon, relying on a cross sectional data, which is indicated by the broken lines in the diagram.

The factors affecting firms' choice will essentially determine the extent of diffusion or the aggregate adoption of a technology within the industry. The framework highlights the aggregate level of adoption because it indicates the extent to which the use of a particular technology is affecting aggregate development outcomes. For example, if it is found that the Chinese technologies are distinctive and produce desirable development outcomes, then the level of adoption will inform us about the potential aggregate development impact within the industry. It therefore gives additional insight into the findings obtained from whether a firm has adopted the Chinese technology or not and why. If very few firms use the technology that produces the desirable development outcomes then that may prompt policies to encourage the adoption of that technology.

It should be mentioned in respect of the above conceptual framework that the intention is not to quantitatively test any hypotheses in this research based on the framework. The main purpose is to use it as a signpost for guiding data collection and analysis, and to help make meaning out of relationships between the concepts or variables that are embedded in the data. Thus, the *logic of inquiry*, a terminology used by Blaikie (2000) and adopted by Potter (2006), for this study is largely **inductive** rather than that based on hypothetico-deduction. The next section describes the broad research approach adopted for the study.

4.3 Research Approach (The mixed methods research)

Many research approaches have emerged so much so that inquirers have many choices, of which three broad examples are qualitative, quantitative and mixed methods approaches (Creswell, 2003). Creswell further notes that the most recent among these three is the mixed methods approach, which is "… still developing in form and substance" (2003 p. 3).

This study adopts the mixed methods approach. Johnson *et al.* (2007) describe mixed methods research as:

> … the type of research in which a researcher or team of researchers combines elements of qualitative and quantitative research approaches (e.g., use of qualitative and quantitative viewpoints, data collection, analysis, inference techniques) for the broad purposes of breadth and depth of understanding and corroboration. (Johnson *et al.*, 2007 p 123)

Thus, rather than relying strictly on either quantitative or qualitative methods, this thesis draws on elements from these two research approaches. This approach aligns with pragmatism as a philosophical viewpoint of research rather than those of positivism/post-positivism or constructionism, which respectively underpin pure quantitative and qualitative research approaches (Greene *et al.*, 1989; Creswell, 2003; Potter, 2006; Johnson *et al.*, 2007). As indicated in the words of Johnson *et al.*, "Today, the primary philosophy of mixed methods research is that of pragmatism" (2007, p 113). Creswell provides a characterisation of the basic ideas behind pragmatism, which has been reproduced in verbatim in Box 4.1 (2003 p.12).

Box 4.1: Creswell's (2003) interpretations of pragmatism
[Based] … on my own interpretation of writers, pragmatism provides a basis for the following claims:

1. Pragmatism is not committed to any one system of philosophy and reality. This applies to mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions when they engage in their research.
2. Individual researchers have a freedom of choice. They are "free" to choose the methods, techniques, and procedures of research that best meet their needs and purposes.
3. Pragmatists do not see the world as an absolute unity. In a similar way, mixed methods look to many approaches to collecting and analysing data rather than subscribing to only one way (e.g., quantitative or qualitative)
4. Truth is what works at the time; it is not based in a strict dualism between the mind and a reality completely independent of the mind. Thus, in mixed methods research, investigators use both quantitative and qualitative data because they work to provide the best understanding of a research problem.
5. Pragmatist researchers look to the "what" and "how" to research based on its intended consequences – where they want to go with it. Mixed methods researchers need to establish a purpose for their "mixing", a rationale for the reasons why quantitative and qualitative data need to be mixed in the first place.
6. Pragmatists agree that research always occurs in social, historical, political, and other contexts. In this way, mixed method studies may include a postmodern turn, a theoretical lens that is reflexive of social justice and political aims.
7. Pragmatists believe (Cherryholmes, 1992) that we need to stop asking questions about reality and the laws of nature. "They would simply like to change the subject" (Rorty, 1983 p. 14).

Creswell's interpretations of pragmatism provided in Box 4.1 show how the mixed methods approach is anchored on pragmatism. Also emphasised in his interpretations is the implication of this philosophical viewpoint for data collection and analysis – both quantitative and qualitative data are used. Later sections of this chapter explain how the mixed methods approach has been adopted for this study with regards to data collection methods employed and analytical tools used.

The mixed methods approach provides many advantages, which rationalise the use of this method. Based on an extensive review of the reasons that are normally cited in methodological writings and research articles for using mixed methods approach, Bryman (2006) provides a long list of justifications for combining quantitative and qualitative research approaches. Of the long list, the following are reproduced here since they informed the decision to adopt the mixed methods approach for this study:

- *Triangulation* or greater validity – Quantitative and qualitative researches may be combined to triangulate findings because the two approaches may mutually corroborate.

- *Offset* – This is based on the idea that the research methods used under both quantitative and qualitative research have their own advantages and disadvantages. Combining them therefore allows the researcher to offset their disadvantages while benefiting from their advantages.

- *Completeness* – The belief is that the researcher can establish a more comprehensive account of the area of enquiry if both quantitative and qualitative research methods are used.

- *Process* – The basic notion is that quantitative research gives an account of structures in social life while qualitative research deals with processes within/between structures.

- *Different research questions* – The argument is that quantitative and qualitative researches can each answer different research questions.

- *Explanation* – Each may be used to help explain findings generated by the other.

- *Unexpected results* – The belief is that the researcher can combine quantitative and qualitative researches to gain more understanding in situations where the researcher generates surprising results from any one approach.

- *Sampling* – refers to situations in which one approach is used to facilitate the sampling of respondents or cases for the other approach.

While all the above reasons underpin the use of mixed methods approach in this study in one way or the other, the most important ones for this study are *different research questions, sampling, explanation and completeness*.

4.3.1 Mixed methods approach for answering the research questions

As mentioned above the different research questions necessitated the use of a mixed methods approach; hence, this subsection describes the specific approach used for each research question. The first research question, which is on the characteristics of the technologies, is answered by using data generated from a semi-structured interview with key informants from a purposive sample of the furniture manufacturing firms. The interviews involved collecting data on the technologies (machines) used by the firms such as acquisition and replacement cost, scale in terms of capacity, maintenance/repair and infrastructure requirements to explore the distinctive nature of the Chinese technology vis-à-vis the others. Data on output and other production inputs such as labour, energy and materials were also collected. The study also relied on observation based on regular visits to the production sites or workshops of the firms. These data collection approaches generated both qualitative and quantitative data. Data that are specific to the technologies (e.g. acquisition costs, output and inputs) are largely quantitative while data relating to respondents' perception, born out of their experience with or exposure to the technologies, are largely qualitative.

For the second research question, the main focus was to determine the mode or mechanism by which the Chinese technologies are transferred in comparison with the technologies from advanced countries. This also relies largely on the semi-structured interviews with the

manufacturing firms, and firms operating in the sales and distribution network of the technologies. These interviews largely generated qualitative data.

The third question requires an approach that would help determine the level of penetration/diffusion of the technologies in the furniture making industry. A structured research instrument (questionnaire)[15] was used to collect data from a cross section of the manufacturing firms. Among other things, but most importantly, the firms were asked to indicate whether they use any of the three technologies (that is, Chinese, advanced country and Kenyan technologies). Information concerning the characteristics of the businesses and their entrepreneurs were also collected. The data collected for this purpose is largely quantitative, based on preconceived categorised responses presented to the respondents. The proportion of the firms that said they use a particular technology, say Chinese technology, provides an indication of the extent of penetration of that technology.

The approach for answering each research question may fall under one of the different typologies of mixed methods approach described by Johnson *et al.* (2007), as shown in Figure 4.2. The figure shows that between pure qualitative and pure quantitative research methods lies a spectrum of approaches that combines the two main approaches but at varying degrees in the two strands. At the middle of the spectrum is the pure mixed method where both quantitative and qualitative strands are given equal importance. Off this middle point lie other forms where "… a second method is embedded or nested within the primary research approach" (Creswell and Plano Clark, 2010 p 10).

Generally, the approach adopted in this study may be located at the middle or very close to the middle of the spectrum shown in Figure 4.2. However, the locations on the spectrum for the approaches used for answering each of the research questions vary. The approach for the first question can be located around qualitative mixed method while that for the second seems to lie well with qualitative dominant method. However, the approach for the third

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[15] All the research instruments used in the data collection have been provided in the appendix section of the thesis.

question has a relatively high degree of the quantitative strand and appears to fall into the region for quantitative dominant method.

Figure 4.2: Graphic of major research paradigms and subtypes of mixed methods research
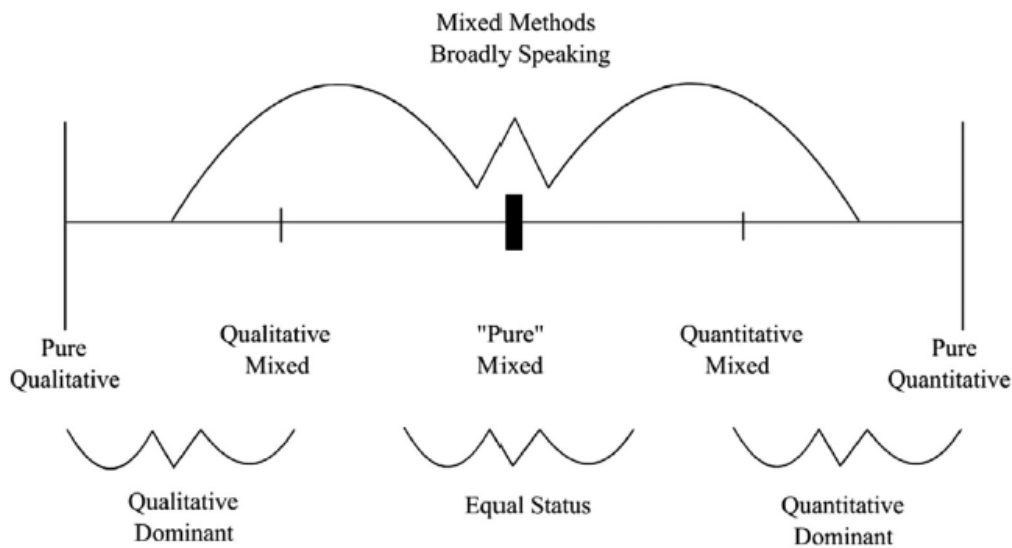
Johnson *et al.* (2007)

For each question, the different approaches used complement each other, thus, providing a relatively *complete* understanding of the issues related to that question. Moreover, they helped to clarify and elaborate the results from each other but particularly using the qualitative data to explain the findings from the quantitative data. Also interesting is that the complementarity between the two strands is used to explore relationships between the concepts or variables across the different research questions. Later discussions in Subsection 4.5.2 of this chapter show how the mixed methods approach helped in sampling some of the respondents interviewed in this study.

4.4 Why Kenya, the selected geographic areas in Kenya and furniture manufacturing?

As noted in Chapter 1, the main objective of the study is to help establish whether Chinese technological innovations are more amenable to industrial development and pro-poor growth in Sub Saharan Africa (SSA) than those from advanced countries. Thus, the country case for the study ought to be one of the SSA countries. However, of the many countries in SSA,

Kenya was selected for two reasons. The first is that being the largest economy in East Africa, Kenya has one of the most vibrant manufacturing sectors in SSA. This has a history in colonisation, particularly the effect of the World War II (WW II) on the policies of the colonial administration on industrialisation in Kenya (Leys, 1975) and stiff international competition to expand international capital after the WW II (Gachino, 2009). Leys (ibid) shows that Kenya was made a "periphery centre" in East Africa, particularly during the WW II, manufacturing basic consumer products to meet the needs of Europeans in East Africa during the war time when it was difficult to import from England.

The second is personal: I did not want to do the data collection in a country I was too familiar with (for example, my home country, Ghana) nor a country I knew very little about in terms of my exposure to the way of life of the people. I lived in Kenya for about 4 months in 2006 so I had a good idea about the likely challenges in the data collection exercise in Kenya. At the same time, I knew that working in a place like Kenya would help me to avoid a lot of distraction from friends, family and other social pressures I would have had to contend with if I had collected the data from a more familiar environment like Ghana.

Two geographic areas (towns) in Kenya were selected for this study: Nairobi and Kisumu. Kisumu is the capital of Nyanza Province in the south western part of Kenya while Nairobi is the national capital located in the central part of southern Kenya. Figure 4.3 shows the map of Kenya and the selected study areas have been encircled in red. These areas were selected because they are known to be major hubs for many formal and informal enterprises. For example, a census of informal enterprises conducted by the Kenya's Central Bureau of Statistics in 1979 shows that Nairobi had the highest number of informal enterprises (nearly half of informal enterprises in Kenya were located in Nairobi), followed by Mombasa (9%) and then Kisumu (7%) (Hosier, 1987). Although this data is old, I believe that the two selected areas still have significant proportions of the firms. Kisumu was selected over Mombasa because Kisumu appears to be a relatively less developed area especially in terms of infrastructure and economic activities, compared to Mombasa while Nairobi is in turn

ahead of Mombasa (Winiecki, 2008). The belief was that using Nairobi and Kisumu might help to examine the technologies in different economic contexts within Kenya.

Figure 4.3: Map of Kenya with the selected study areas encircled in red

The study concentrates on urban areas because usually vibrant or well-functioning manufacturing firms (in this case furniture making firms), whether formal or informal, are located in urban areas. In rural areas, manufacturing is usually undertaken as a secondary occupation to agriculture largely because of low demand for manufactured products.

Having settled the issue around the country and specific geographic areas for the study, the next issue to deal with was the industry or the manufacturing subsector to study. Though Chinese technologies may be used in many industries in Kenya, the study concentrates on

the furniture making industry. The rationale is as follows: This industry plays a central role in informal sector manufacturing and in the manufacture of products for the poor, as was indicated in Chapter 2 Subsection 2.2.3. It also has an active formal sector. It therefore allows comparison between formal and informal sector usage of Chinese technology vis-à-vis the other types of technologies. Moreover, it is one of the manufacturing subsectors in Kenya with a very high employment creation potential, as was noted under Subsection 2.2.3 of Chapter 2.

4.5 Data collection approach and sampling methods

Two rounds of data collection were carried out. The first round involved collecting largely quantitative data with a structured questionnaire from a sample of the firms operating in the identified locations. As alluded to earlier, this was mainly to generate data to answer the third research question. Though the main purpose was to collect quantitative data, I also observed the production processes of the firms, the conditions of the firms' location, the technologies they use and market dynamics. The second round of interviews involved collecting largely qualitative data from a purposively selected subsample of the firms interviewed in the first round but with much focus on the economic and technical characteristics of the technology types and the transfer modes. The subsections that follow describe how the firms were selected in each round of the data collection as well as the sampling approaches adopted for other participants in the study.

4.5.1 First round of interview with the manufacturing firms

A key issue here relates to how the firms were identified, particularly with respect to the formal or informal status of the firms. Theoretically or conceptually, there appears be to a limited consensus on how to characterise the informal sector. Consequently, more than one criterion for identifying informal sector firms is usually adopted in many studies (e.g. ILO, 1972; Bigsten *et al.*, 2000; Becker, 2004). This research did not rely on any strict operational definition or criteria for informal sector firms to inform the data collection, thus, the data collection approach adopted largely refrained from tagging any firm or groups of firms as

informal. The reason for this approach was to allow the data to tell which firms are formal or informal based on their characteristics. However, it should be noted that the informal status of most of the firms was obvious, even based on casual observation. This is in accordance with Altman's statement that "Many researchers say 'you know it when you see it, but it can't be defined'" (Altman, 2008 p 5).

The strategy adopted for the sampling was to identify groups of firms by their locations (that is, whether they are clustered at specific locations) and then sample from the firms operating in these locations or clusters. Four locations were identified for the study: Gikomba cluster, Ngong' cluster, Kibuye cluster, and another group of firms mainly operating in Nairobi's Industrial Area (and surroundings) and along the Mombasa Highway in Nairobi, which are relatively large in scale. (From now on, the last set of firms will be referred to as Industrial Area firms in order to simplify discussions).

Compared to the Gikomba, Ngong' and Kibuye cluster, the Industrial Area firms are sparsely located within the identified location. Apart from the Kibuye cluster which is located in Kisumu and along the road connecting Kondele and Kisumu's city centre, the rest are in Nairobi. The Gikomba cluster occupies the thin stretch of land between the Kamkuji Road and the Nairobi River, which passes through the Gikomba market in Nairobi. The Ngong cluster is opposite Nairobi's Race Course, and stretches along a portion of the shoulders of the neatly tarred Nairobi-Ngong' Road. It should be noted that two other locations in Nairobi – along Juja Road and in Githurai – were also identified but they were not included in the study. They were excluded because of the limited time and other resources for data collection. Moreover, the Juja Road and Githurai clusters look much like the Gikomba and Ngong' clusters respectively though both are much smaller than their respective comparators. The subsections below describe how the firms in these locations were selected for the first round of the data collection.

Gikomba, Ngong' and Kibuye Clusters

Using a systematic random sampling technique, the firms in the above clusters were selected from a sampling frame for each cluster that I developed by *listing* all the firms in each clusters. The reason for using systematic random sampling was to ensure sample representativeness for each cluster. The listing was done in the absence of an already existing database or register on these firms. Basic information about the firms such as the name of the firm (if available) or the name of the operator, contact number of the operator (if the operator did not mind giving it out) and a description of the firm's specific location were obtained.

Table 4.1: Sampling strategy for firms in Ngong', Gikomba and Kibuye clusters

Clusters	Number of listed firms (N)	Number of firms selected (n)	Number of firms actually interviewed (n)
Ngong'	149	50	53
Gikomba	91	30	25
Kibuye	98	33	33
Total	338	113	111

The total numbers of firms listed in the clusters were 149, 89, and 98 respectively for the Ngong', Gikomba and Kibuye clusters. Had it not been for limited time and resources, all the firms that would agree to take part in the study should have been interviewed given that these numbers are not large. In the light of the above challenge, the strategy adopted was to interview about a third of the listed firms in these clusters, which appears to be an adequate representation for each cluster. Table 4.1 shows the actual number of firms interviewed in these cluster.

It should be noted in respect of the Gikomba cluster that the number of firms listed as shown in the table represents the number of sheds rather than the firms. I found during the listing

exercise that some of the sheds or working areas accommodate more than one than person, who operate independently but are involved in the same activity or product lines. For a lot of such cases, the operators had similar backgrounds, particularly in terms of age and tribe. The strategy was therefore to list the sheds and interview an operator or any firm within each shed or working area that was ready to take part in the study. This strategy helped especially in the light of the fact that a relatively large number of the prospective respondents in this cluster shied away from participating in this research for reasons discussed later under Section 4.6.

Industrial Area

For the relatively large-scale firms operating in the Industrial area and along the Mombasa Highway in Nairobi, the initial strategy was to obtain a list from the office of Kenya's Registrar of Businesses, from which to select systematically a sample of those firms. This, however, proved futile as information obtained from the Registrar of Businesses indicated that the register of firms does not categorise firms by sector of operation. Unlike the other firms, the sparse nature of the specific locations of the Industrial Area firms also made listing daunting if not impossible especially without any knowledge of their specific addresses. I therefore resorted to two sources of information about the firms and their addresses: Kenya Yellow Pages Online and Kenya Association of Manufacturing (KAM) – the office[16] and their annual directory of manufacturing firms in Kenya.

Putting the sets of list from these sources together gave a total of 47 firms. Of this number, 14 came from KAM while the rest were from the Yellow Pages. It is difficult to say that this list was exhaustive. However, the 2006 KAM report titled "Manufacturing in Kenya" suggested that as of 2002, Kenya as a whole had 68 furniture-manufacturing firms of the scale or calibre of the firms operating in the Industrial Area. The report further suggested that not all the firms were operational as of 2006 as a result of a ban on logging that took place in the early 2000s.

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[16]I wrote a letter to Kenya Association of Manufacturing requesting them for a list of furniture manufacturing firms operating in Nairobi. What was available from them was the list of firms that were part of their membership.

With this list, I attempted tracing all the firms. In the end, I was able to trace 31 firms, of which 20 were interviewed. Some of the firms on the list could not be located with the addresses from the Yellow Pages because the page had not been updated for a while. The firms had either moved locations or folded. For example, on one of my data collection rounds, as I stood in front of the shut gate of what used to be the premises of one of the firms, a passer-by informed me that the firm had collapsed not long ago. Some of the firms were also not willing to take part in the study, which they indicated right from my first visit to them while others clandestinely avoided me. Two additional firms I visited (whose addresses were obtained from the Yellow Pages) were also in retail rather than manufacturing. The consequence was that instead of following a strict systematic random sampling method, I ended up interviewing those I could find and were interested in participating in the study.

4.5.2 Second round of interviews with the manufacturing firms

As noted earlier, data (largely qualitative) from a purposive sample[17] of the firms were collected for exploring the distinctive characteristics of Chinese technologies and the transfer mode in relation to the other technologies. This constituted the second round of interviews, of which the participants were purposively selected from those that took part in the first round of interviews. In fact, all the respondents in the first round were asked to indicate whether they were interested in the second round, of which everybody said they were interested. The first round of interviews therefore provided an avenue to solicit the firms' consent for the second round of interviews, thanks to the mixed methods research approach. The consent was sought at the end of each interview. The firms were however informed that their participation in the second round was not automatic but depended on the findings from the first round of the research.

The first round of the data collection also helped the second round in a more important way. Furniture manufacturing is characterised by the production of a wide range of heterogeneous products with equipment and machines that vary in nature and in use. The implication for the

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[17]Purposive sampling, also called *judgment* sampling, is a non-probability sampling technique, which involves selecting study participants deliberately because of some qualities/characteristics they possess (Tongco, 2007; Burgess, 1984).

study was that it was crucial to identify some specific areas of the production activities and equipment used in performing these activities which lend themselves to comparison across firms in the different clusters. The first round of interviews and visits to the firms therefore provided information that helped to deal with the above-mentioned challenge. It provided answers to questions like which kind of machines are common across the different firms and technology types (sources), what are they used for and in what clusters do the firms that use these machines operate? The answers to these questions formed a significant component of the criteria used for selecting the purposive sample of the firms.

The first round of interviews with the firms and my observations therewith showed that the production activities of the firms could be broken down into four parts: Designing; preparing components or parts; joinery; and finishing and upholstery. I found that preparing components was the most technology (equipment) intensive of all the activities, involving planing, ripping, crosscutting, turning etc. Moreover and in general, these activities particularly planing also produce outputs that are relatively easy to measure and compare across firms and the technology types. The machines used for these activities, which were the commonest across the majority of the firms and the technology types were planing machines/thicknesser, saw bench, lathe and band saw, which are all automated "light-duty" machines. Hence, the second round of interviews focused on these light-duty machines and each of the firms selected had at least one of these machines.

It should be noted that not all the firms interviewed in the first round of the interviews had invested in these automated light-duty machines. While they produce furniture, some have only invested in manual and/or power hand tools and relied on machining services provided by other firms. (Detailed discussion on this issue has been provided in Chapters 5 and 8). In order to limit this PhD to a manageable scope, the thesis pays little attention to hand tools especially with respect to the detailed study of the characteristics of the technologies from China and the other sources. The first round of the interviews therefore helped to identify firms that have invested in the automated light-duty equipment considered in this thesis. At same time, the random inclusion of those that have invested only in hand tools in the first

round of the survey helps to determine the extent of penetration among all the furniture manufacturing firms in the study area rather than simply the sub population that has invested in the automated equipment.

Another criterion that informed the selection, though to a more limited extent, was the scale of operations of the firms (that is, whether micro, small, medium or large enterprises). In Kenya, scale is normally defined in terms of the number of employees working in an enterprise: Micro enterprises are those with 10 or fewer workers, small enterprises have from 11 to 50 workers, and medium enterprises have from 51 to 100 workers while large enterprise have over 100 workers (Gray *et al.*, 1996).

Of a total of 131 firms interviewed in the first round, 41 were selected for the second round of interviews, of which eight were from the Industrial Area category of firms and the rest were from the Ngong', Gikomba and Kibuye clusters.

4.5.3 Sales and distribution firms of the technologies

Based on anticipated challenges such as lack of geographic clustering of these firms and a relatively low interest on the part of these firms to participate in the study, the initial plan was to use a snowball sampling approach to recruit these participants. Snowball sampling is a type of purposive sampling method in which the researcher depends on the social networks of participants he has already interviewed or contacted, where such participants refer the researcher to other people who could potentially participate in the study (Wilson, 2005). Hence, it is also referred to as *chain referral sampling.* The specific strategy was to ask the firms that took part in the second round of interviews to give referral to the firms that supply the machines.

The above strategy however did not work perfectly. While many of the firms mentioned the names of the suppliers and their locations, they could not or would not introduce me to any of the sales and distribution firms. The reason was that for most of them the machines of the kind under study are not items they purchase on a regular basis; hence, they do not have

strong ties with the suppliers so that they could introduce to those suppliers a researcher who might pester them for an interview appointment. Some of the machines were also bought straight from foreign dealers. The information the manufacturing firms provided on the names and locations of the suppliers was however valuable in the sense that it helped to trace the firms. I visited many of the supplier firms but only four granted interviews, of which three operate in Nairobi and the other one in Kisumu.

4.5.4 Other key informants

Interviews with other key informants such as officials of associations of the firms, government ministries and agencies were part of the data collection plan. The aim was to determine if they play any role in the transfer of the technologies and for that matter the technology choice by the firms. My interactions with the firms during the first round of interviews showed that associations had virtually no role to play in their access to technologies. However, I had a relatively short interview with an official of the jua kali association in Kisumu because that was where I found a relatively vibrant jua kali association, of which some of the furniture making firms in Kibuye were members. I also had another short interview with an official of KAM over the phone. Both confirmed that the associations play little or no role in the firm's technology matters. The information from these interviews therefore does not feature in the discussions in the analytical chapters of this thesis.

Similarly, interviews (also short) were held with three officials of government ministries (Ministry of State for Planning, National Development and Vision 2030, Ministry of Industrialisation and Ministry of Labour), an official from the Kenya Industrial Property Institute and another one from the Kenya Industrial Research and Development Institute. These interviews showed that government does not play any direct role in the technology choice and technology transfer for the firms in the furniture making industry. When asked about government policies and their implication for manufacturing in Kenya, they produced several government policy documents for me to study. I had already chanced on some of those documents when I was writing Chapter 2 of this thesis, which was initially drafted

before the fieldwork. The new documents were used to improve the Chapter 2 during the latter part of this thesis preparation.

The official from the Ministry of Industrialisation however noted that the Kenyan Government has taken a special interest in furniture manufacturing in the country with a presidential directive that procurement of furniture for public offices be restricted to furniture made in Kenya. He indicated that the volume of this procurement is estimated to be around 2 billion Kenyan Shillings[18] per annum; hence, the aim of the directive is to shore up the furniture making businesses to create more wealth and employment. With a policy guideline on this directive in place, he noted that plans were far advanced to implement the directive of the President. It should be noted that this development adds to the attractiveness of studying the furniture industry rather than any other manufacturing subsector.

Another group of informants for the study were repairers and/or fabricators of locally made machines. Five of these informants were interviewed, of which four were among many others operating in a close vicinity to the Gikomba cluster in Nairobi while the remaining one operated in Kisumu. It was relatively difficult to find fabricators around Kibuye and in Kisumu. The purpose of these interviews was to obtain a second opinion on some of the data collected from the manufacturing firms during the second round such as cost of repairs, quality and robustness of machines and the availability of skills for repairing the machines.

4.6 Other field challenges

Several challenges including sampling difficulties faced during the data collection have already been mentioned. This section however highlights a few additional challenges.

4.6.1 Language issues

Though Kenya is an English-speaking country, some of the respondents especially those in Gikomba and Kibuye clusters could not communicate well in English but in Kiswahili, which I was not very familiar with. Hence, I had to hire a research assistant who helped me to

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[18] The exchange between the US dollar and Kenya Shilling was 85 shillings per one US dollar at time of the data collection.

communicate with both prospective and actual respondents who could not speak English to a satisfactory level. I practiced with the assistant on how to translate the interview questions/ questionnaire into Kiswahili in order to ensure that the right responses were solicited during the interviews. Instead of allowing him to conduct the interviews, he only served an interpreter while I conducted all the interviews. This strategy offered me the opportunity to ask follow-up questions specific to each respondent but were not written on the interview guide or questionnaire. The research assistant could not have asked the right follow-up questions because he did not have in-depth knowledge about the subject area under study.

Another language challenge was the difference in my Ghanaian English accent and that of the Kenyan people. However, I became very used to the Kenyan English accent after a brief period (about one to two weeks) while some of my respondents struggled with my accent. The research assistant did a good job by intervening any time accent problems arose. He also helped in locating places and offices I had to visit during the data collection.

4.6.2 Earning the trust of prospective respondents

Gaining the trust of prospective respondents was difficult, particularly in the Gikomba cluster. While an introductory letter from the Institute for Development Studies (IDS) of the University of Nairobi (my affiliate institution in Kenya) and my student ID card generally helped, it was still difficult for some of the prospective respondents (especially the Gikomba firms and sales and distribution firms) to grant me audience, particularly at the first instance of my interactions with them. An account of one of my experiences with a prospective respondent in the Gikomba cluster is instructive: When we (the research assistant and I) approached him, he asked to be excused for a minute. After a few minutes he came back to us but with an amulet on his wrist, something he did not have on him when we approached him.

It should be noted that the relatively high difficulty in gaining the trust of the prospective respondents in the Gikomba cluster was largely responsible for the relatively large non-response rate for this cluster as the figures in Table 4.1 indicate. For the sales and distribution firms, some of them were not sure about our credibility and some believed that

we were looking for business secrets. One of them said that he could only talk to us after 4 pm, by which time they had sent his daily sales or revenues to the bank.

There was also some problem of trust with the officials from the government ministries/agencies. While they had little or no doubt about my student status and that I was collecting data for school work, only one person allowed voice recording of the interview. They gently declined by asking: "Are you sure you are not from the media?" and then suggested that I take notes instead of recording the conversation.

4.6.3 Getting interview appointments

Apart from the difficulty in locating the firms operating in Industrial Area, there were also challenges with respect to gaining their consent to participate in the study. The security personnel and/or receptionists of the firms appeared to avoid appointments with the managers/ directors of the firms especially when the purpose for the appointment seemed to provide little or no business opportunities. They would normally take the letter officially asking for appointment or their participation in the study and either refused or failed to fix any appointment. Some of them gave out email addresses to reach the managers or directors but I did not receive any reply to my emails on many of those instances. For some of the firms, however, persistent or repeated visits to them proved beneficial while others never gave in.

4.6.4 Elections and electioneering campaigns

The data were collected between August 2012 and January 2013. This period coincided with the run up of electioneering campaigns of the 2013 Presidential and Parliamentary Elections in Kenya. Particularly in Kisumu, some of the campaigns ran at the same time I was conducting interviews. While this might have some implications for the data, those implications are much less significant in that the subject area for the study did not appear to be politically sensitive for the respondents. The only difficulty was that it affected the attention of the respondents who were interested in politics. There were several instances where I had

to discontinue an on-going interview and asked for a second appointment because the respondents' attention was drawn to a political campaign at a nearby location.

4.7 Tools for data analysis

The qualitative data (interviews and field observations) were analysed by the thematic approach. This involved identifying patterns in the data and organising them into coherent themes, which does not involve assigning numerical codes as it is done in quantitative analysis. This was very labour intensive, involving reading and re-reading to summarise and bring meaning to the text. Rather than relying on preconceived themes, the themes used in the analysis emerged from working with data. Descriptive narrations including reference to specific statements from the respondents were then used to discuss and present the data under each theme, sub themes and relationships within and between the themes. All the interviews (i.e. qualitative or narrative data) were transcribed before the analyses were done.

Numeric data gathered on outputs and inputs (labour and capital) of the firms at the preparation stage of the production process (and specifically in relations to planing) were also used to compute technical coefficients of production. Three coefficients calculated were capital-labour ratio, output-labour ratio and output-capital ratio, which give indication about the relative factor intensity and relative efficiency of the different technology types considered in this study. With additional data such as unit charge on planing a foot of a given dimension of timber and other input costs incurred from using the planing machine, discounting measures such as net present value (NPV) and benefit cost ratio (BCR) were calculated to determine the profitability or return on investment in the technology types. Specific details about how the production coefficients and the indicators on returns on investment were calculated are discussed in Chapter 7, which among other things examines these concepts.

Descriptive statistics and regression models were also applied to analyse the quantitative data from the first round of interviews. This data analysis was done using STATA. Descriptive statistics such as means, frequencies and percentages were generated. Chapter 5, which discusses the profile of the firms and their operators, relies extensively on

descriptive statistics. The regression models were used to analyse the relationship between the firms' technology adoption decisions and their characteristics including those of the operators. It was also used to examine the complementarity between the adoption of Chinese technology and the others. Specific details about the regression models used are presented in Chapter 8 where the analyses and discussions have been presented.

4.8 Conclusion

This chapter has focused on the conceptual framework and the research method employed to answer the three research questions. The chapter has provided justifications for the use of a mixed methods research approach and elaborated on the specific sampling techniques used to recruit the various respondents. Among the respondents are the furniture manufacturing firms, sales and distribution firms of the technologies, and fabricators of locally made machine, who also repair the other machines. The data collection techniques and analytical tools employed have also been explained. The next chapter present a discussion on the business and entrepreneurial profile of the firms interviewed.

CHAPTER 5 : BUSINESS AND ENTREPRENEURIAL PROFILE

5.0 Introduction

Based on data collected from the 131 furniture manufacturing firms, this chapter presents the business and entrepreneurial profile of the firms, highlighting the differences in them with respect to the clusters/sector in which they operate. The main aim of the chapter is to help understand the nature and characteristics of the firms studied in this research. Moreover, as explained in Chapter 3 (which reviewed literature relevant to the research questions) and Chapter 4 (which presented the conceptual framework explaining the general relationship between the key variables/concepts used in this study), the characteristics of the firms including their operators are key to gaining more than an intuitive understanding of the behavioural patterns of the firms, particularly in relation to technology choice and the choice of transfer mode for a particular technology.

However, I do not attempt to explore how or the extent to which these factors influence technology choice in this Chapter. I rather leave such discussions for subsequent chapters particularly Chapter 8. Thus, the discussion in this chapter provides information that will help in later chapters to explain the pattern of technology adoption across the firms and the extent of diffusion of the technologies across clusters/sectors. It also helps contextualise the various findings presented in later chapters and tease out the development policy implications. The discussion also provides a rationalisation for delineating "formal" sector firms from "informal" ones. This categorisation is important for later discussions in subsequent chapters and enhances insight about the development implications of technology choice between the formal and informal sectors.

The discussion covers a number of indicators needed for profiling the firms and their entrepreneurs. These represent an attempt to profile the firms operating in the furniture making industry in Kenya. However, it should be noted that the indicators discussed may not be exhaustive, as for example, the financial performance of the firms are not discussed

mainly because the necessary data were not obtainable from the majority of the firms. The discussion proceeds by first presenting a description of some of the social and economic dynamics within the clusters since the cluster in which a firm operates is indicative of some inherent attributes of the firm. This is followed by a discussion about specific characteristics of the firms, which may vary across firms between and within clusters. Last but not the least, the characteristics of the firms' operators are discussed before turning to a series of concluding remarks.

5.1 Cluster-level dynamics or features

Industrial clustering has been well studied and the literature (e.g. McCormick, 1999; Rabelloti, 1999; Schmitz, 1999; Bell and Albu, 1999) suggests that clustering influences the nature of firms' operations. With a theoretical framework, Bell and Albu (ibid) suggest that cluster dynamics can influence the technological capabilities of firms, which include investment in machinery and equipment. This section therefore discusses cluster-level characteristics of the furniture making firms while highlighting some of the challenges they pose to the operations of the firms.

To a large extent, the magnitude of the challenges that the cluster characteristics or factors pose can be easily 'normalised' across firms within a particular cluster. However, the actual effect of the challenges at the firm level may depend on the varying levels of the firms' capabilities to respond to the same magnitude of threats or opportunities. For firms operating in different clusters, however, not only do their individual capabilities to manage threats or embrace opportunities matter but also important is the different degrees of threats and opportunities they may have to face. The discussions in the subsections that follow will centre on three headings: business registration and tax obligations; the nature of infrastructure; and trust and social relations.

5.1.1 Business registration and tax obligation

This subsection deals with the business registration status of the firms (that is, whether a firm has registered or holds a business license to operate) and the nature of the tax regime the firms face. The respondents were asked to indicate whether they have registered their firms with the Registrar of Businesses for which a certificate has been issued. Of the 131 firms interviewed, 31.3% representing 41 firms are registered businesses. Thirty four percent (34%) of the firms in the Ngong' cluster (i.e. 18 respondents) reported that they have registered their firms compared to one respondent in the Gikoma cluster and two respondents in the Kibuye cluster. Though registered, the mode of operations of these firms does not differ from those that have not been registered, particularly with regards to the following: employment conditions; scale of operation; competition pressures; and bookkeeping practices. Bohme and Thiele (2012) refer to such firms as "registered informal enterprises". The observation also accords with Nattrass's (1987) belief that business registration (or licensing) status of a firm may not be an adequate criterion for distinguishing formal sector firms from informal ones. It does not however support the approach of studies such as ILO (2002) and Cling *et al.* (2011), which essentially equate business registration with formality.

The relatively large scale firms operating in Nairobi's Industrial Area and along Nairobi-Mombasa Road have all been registered. Unlike the other firms operating in the three clusters mentioned above, these firms keep a more structured bookkeeping system and are expected to pay corporate taxes on profits. For the firms operating in the other clusters including the Ngong' cluster, none keeps structured or proper books of accounts let alone pay corporate tax on profits. In fact, my attempt to solicit information on their profits proved difficult to the extent that I gave up on it. Hence, instead of corporate taxes they are expected to pay a weekly or daily levy, collected by city councils (that is, Nairobi City Council for Ngong' and Gikomba clusters and Kisumu City Council for Kibuye cluster), which regulate the activities of these firms including the unregistered ones. Those operating in Nairobi pay Two Hundred Shillings per week while those in Kibuye pay Thirty Shillings per day.

If one characterises formality as involving business registration and payment of corporate taxes then all the firms in the Gikomba, Ngong' and Kibuye clusters are not formal enterprises while their counterparts are. On the other hand, one can also say that all the firms have some degree of formality to the extent that they pay some form of taxes and are somewhat regulated. As noted in Chapter 4, the literature on the definition of informality is not conclusive. Becker (2004) argues that this arises from the intrinsic heterogeneity of the informal sector, which has been documented in the literature (e.g. Brand, 1986; Granstrom, 2009; Grimm et al., 2011). With respect to the firms studied in this research, I will provide a dichotomy between the formal and informal sectors and emphasise the heterogeneity of the latter in the light of the data and the literature on informality at the concluding section of this chapter. The reason for this deferral is that some of the discussions in later sections of this chapter provide further information, which helps in the attempt to obtain a better characterisation of what I will refer to as the informal sector throughout this study.

In the meantime, I will *loosely* refer to all the firms in Gikomba, Kibuye and Ngong' clusters as **informal** sector firms and their counterparts operating in the Industrial Area and along the Nairobi-Mombasa road as **formal** sector firms. Suffice it to say that this approach has been adopted at this stage mainly as a way to help nuance the discussions with comparisons between what I now refer to as the formal sector firms and the others. However, the major differences and similarities in the firms across the different clusters are highlighted throughout the discussions.

5.1.2 Nature of housing and infrastructure

The quality of shed or premises and infrastructure (access roads and power supply) may influence the nature of business activities in the clusters. Similarly, it is likely that the nature of housing and infrastructure in these clusters can also influence technology choice of the firms. Stewart (1982) shows that infrastructure is critical for technology choice. Hence, the discussion in this subsection examines the quality of infrastructure/housing in each cluster while highlighting the major differences across the clusters.

Gikomba cluster

The operators in this cluster hire spaces from 'squatters' on a thin stretch of land lying between the Nairobi River and the Kamkuji Road. A part of this land may have been left for a pedestrian walkway and the other part for accommodating the river when it overflows its banks, giving some indication of the 'temporary' nature of the location of this cluster although it has existed for several decades. Another indication of the temporariness of this location relates to the nature of the sheds in which the firms operate. Almost all the sheds are made from wood and/or dilapidated aluminium sheets as it can be seen from Figures 5.1 and 5.2. My interaction with the operators shows that they usually have to raise the money for mounting the sheds or refurbishing an old one. Such costs are then set off against a fixed monthly rent for the space until the operators fully recover the expenses, after which they have to pay a monthly rent to the landlords for the rest of the period they will operate in the shed. For potential entrepreneurs, the initial cost of constructing the shed can become an entry barrier or a challenge especially when the entrepreneur is unable to find an already-built shed.

A careful look at Figure 5.1 and 5.2 reveals many more challenges the firms operating in this cluster face on a daily basis. First, these sheds have open entrances (that is, they have no doors), indicating that security is a serious challenge in this cluster. Interestingly, the operators leave their tools, machines and wares in these sheds after work. While hand tools are normally locked up in toolboxes, light duty machines are left openly in the sheds. The operators indicated that they have had to endure high degrees of theft and pilferage which happen at night. Often, they wake up to find parts of their light-duty machines stolen or someone has made away with hand tools after breaking into the toolbox or both. As a way of resolving this problem, the operators contribute money which is used to hire guards to watch over the sheds at night. This has only provided a partial antidote in the sense that their total contribution is usually not enough to hire an adequate number of guards needed to deter thieves from the sheds.

Figure 5.1: Back view of a section of Gikomba clusters
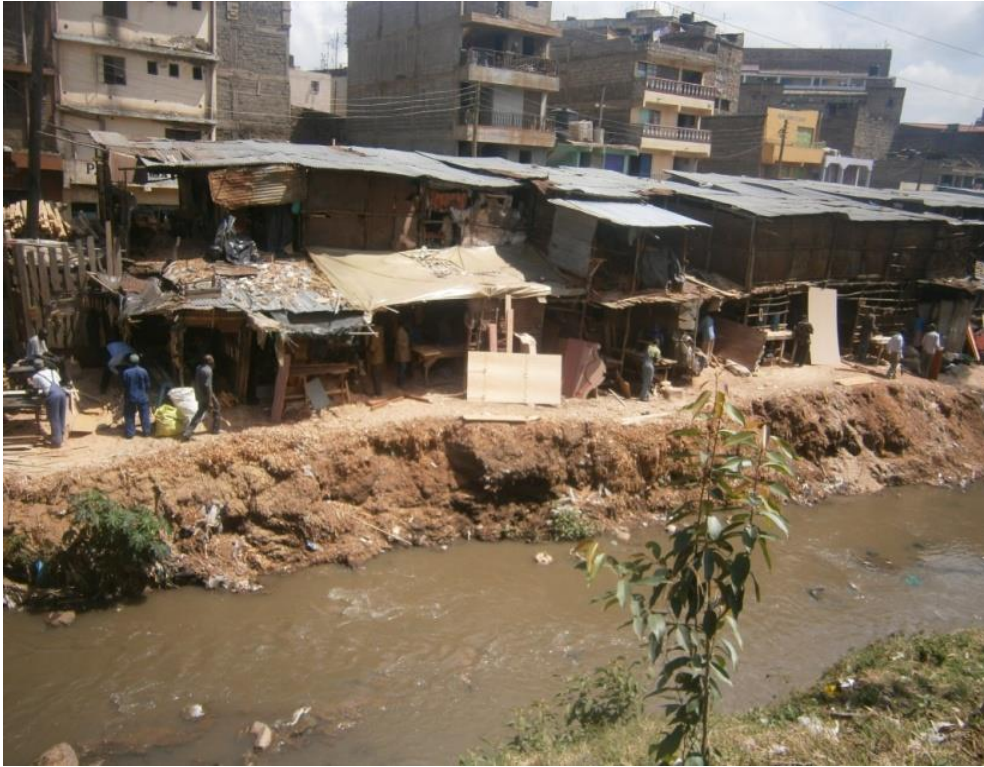
Source: Author's field photography, 2012

Figure 5.2: Front view of a section of Gikomba cluster

Source: Author's field photography, 2012

Second, the sheds are prone to fire outbreaks. The operators reported that fire outbreaks have repeatedly destroyed their sheds including their equipment (tools and machines) and wares. One of them reported that in the last five years alone, they have had three fire outbreaks and he has been a victim in each case, which has significantly affected the growth of his business. His words make this point more graphic:

> I always come… to square one after each fire outbreak. I lose my materials, the furniture I have made and even some of my tools and machines. See, the planing machine [over] there is no longer in use because the main [essential] parts such as the motor, capacitors and switches were burnt in the last fire outbreak. … losing materials and wares is serious than the machines because the machines I buy with my own savings, [while] the money invested in materials normally come from customers who have order with me" (Field interview, 2012).

Another person reported that he lost so much in a fire outbreak that occurred in 2008 to the extent the thought of it had adverse impact on his health: "…after the fire, I became sick and the doctor said my blood pressure is high and now I take medicine every day because of the pressure" (field interview, 2012).

The third challenge is that the firms operating in this cluster experience difficulties when it rains heavily. Though the rains normally offer a temporary relief from the effect of the hot sun, it introduces them to another form of hardship. The rains turn the major access route (the dusty Kamkuji Road which passes in front of the sheds) into a mud trap as can be seen in Figure 5.2. Whenever it rains, vehicles experience difficulty in plying this road and the popular two-wheel handcarts pictured in Figure 5.2 become less useful. The muddy road does not only affect the work of the handcart operators but also the carpenters. The reasons are that the carpenters rely extensively on these handcarts for moving materials to their workshops and for transporting furniture to their customers. Additionally, the muddy road deters customers from visiting the carpenters' workshops.

Another effect of the rains worth mentioning, and evident in Figure 5.1, is that the Nairobi River floods from continuous or heavy downpours, usually inundating the sheds with water and sometimes sweeping away wares, tools and machines. Figure 5.1 was taken a day after a little downpour which caused a significant rise in the water level, indicating the extent of disruption a heavy downpour can cause. Moreover, with floors buried under wet sawdust and

wood shavings, the rains expose the operators to the risk of electrocution because the sheds are cluttered with naked live wires, which is the result of irregular and illegal electrical connections.

Such electrical connections are mainly the result of the lack of direct access to power by almost all the operators, which represents the fourth challenge. The 'landlords' have taken advantage of this situation. They obtain power from Kenya Power, the main supplier and distributor of electricity in Kenya, and then sublet the power to the operators at a fixed fee per day. The fixed fee however varies with respect to the number and type of machines an operator has. For example an operator with a band saw pays one hundred Kenya Shillings per day while one with only a jig saw pays Fifty Kenya Shillings per day irrespective of the actual length of time the machine is operated on each day. The operators believe that the landlords have created rent out of the power supply. According to them, the landlords are able to realise revenues well over what they pay to Kenya Power. They find the daily fixed fee to be exorbitant, increasing their cost of production.

Ngong' cluster

As mentioned earlier in Chapter 4, the Ngong' cluster is opposite the Ngong' Race Course in Nairobi and stretches along the shoulders of the neatly tarred Nairobi-Ngong' Road. Unlike Gikomba, the access route to the Ngong' cluster is never a problem during a rainy or a sunny day. However, traffic on this road becomes intense during rush hours. Moreover, the unpaved shoulders of the road which the operators use for displaying their products, as indicated in Figure 5.3, become a bit muddy and less suitable for such purpose when it rains. It is also important to note that the operators in this cluster do not struggle with flooding and neither do they struggle with theft and pilferage to the degree confronting their counterparts in the Gikomba cluster. This generally suggests that the security of wares, tools and machines is better at the Ngong' cluster than at the Gikomba cluster.

Figure 5.3: A section of Ngong' furniture cluster

Source: Author's field photography, 2012

Figure 5.4: Examples of permanent structures at Ngong' cluster

Source: Author's field photography, 2012

One major reason for the better security at Ngong' relates to the nature of the sheds available in this cluster. The majority of the operators in this cluster operate in more permanent facilities, which is usually constructed with cement blocks and roofed with aluminium sheets with relatively secure doors and locking systems, as Figure 5.4 confirms. The operators however noted that their location is "temporary" because much of it is part of the portion of land left for the expansion of the Nairobi-Ngong' Road. According to them, they had heard rumours that the road expansion was due to happen any moment from the time of my data collection. Another problem is that their sheds are usually not spacious enough to accommodate all production activities. Consequently, much of the production work especially the joinery aspect is usually done outside while the machine work (e.g. splitting, planing and lathing) is done inside the sheds where the machines are normally mounted. Although some of the operators in the Ngong' cluster also use temporary structures (made from wood and used aluminium sheets), unlike the Gikomba cluster, the temporary sheds at Ngong' normally do not have open entrances, at least not for the section of the sheds where machines and tools are kept overnight. Correspondingly, no respondent at Ngong' cluster mentioned theft and pilferage as a major challenge facing their businesses.

Another reason for the better security at the Ngong' cluster is that it is less congested and less prone to fire outbreaks. As one respondent indicated, "we have not had any fire outbreak since I started operating here about five years ago … but we are still a bit prone to fire outbreaks. Well, I also don't know whether there was any fire outbreaks before I came [here] but if there is any I should know by now". A major factor that may have prevented fire outbreaks in this cluster is that the majority of the operators have direct access to power supply from Kenya Power; hence, irregular and illicit electrical connections are limited compared to the Gikomba cluster.

Kibuye cluster

The sheds in Kibuye cluster are similar to those found in the Ngong' cluster. The cluster has permanent structures similar to those found at Ngong' as well as temporary structures

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although the temporary structures are slightly fewer. Normally, those operating in permanent structures also build temporary extensions in front of their sheds, as Figure 5.5 depicts. Like the Ngong' cluster, a lot of the joinery work is done outside the shed, usually under the extensions, while the finished product, work in progress and materials are kept inside the sheds. In most cases, the light-duty machines are operated outside the sheds as depicted in Figure 5.5 and moved into the shed after the day's work. Thus, like the Ngong' cluster but in contrast to Gikomba, the sheds in Kibuye are relatively solid.

Figure 5.5: An example of sheds at Kibuye cluster

Source: Author's field photography, 2013

However, with regards to fire outbreaks, Kibuye is not so different from Gikomba. The operators reported a number of fire outbreaks at Kibuye, with many of them having been victims. Again, illegal and irregular electrical connections could be a major explanation for the rampant fire outbreaks at Kibuye since a lot of the operators do not have direct access to power supply from Kenya Power. To forestall further fire outbreaks and prevent loss of property, the landlords at the Kibuye cluster are converting the temporary structures into

permanent structures, which are less prone to fire. This has led to an increase in the cost of production of the firms because the rent for a permanent structure is about three times that of a temporary structure.

Another good feature of the Kibuye cluster is that the structures are better organised compared to those in Gikomba, making it less congested and the major access route to the cluster is also less muddy when it rains. This route is a minor branch of the dual-carriage street connecting Kondele and Kisumu city centre.

Formal sector

As noted in Chapter 4, the formal sector firms are generally located in Nairobi's Industrial Area and along the Mombasa highway, which together cluster formal manufacturing and industrial activities in Nairobi. The premises of these businesses are fenced with tall concrete walls, and sometimes, the concrete walls are extended with an electric fence. These gated premises almost always have a security post with 24-hour security surveillance, at least, at the entrances. The first point of call of any visitor is the security post where suspecting individuals are either denied entry or allowed entry after a brief questioning and security checks. Figure 5.6 shows a picture of a formal sector furniture manufacturing firm, depicting the relatively magnificent nature of the kind of edifice in which these firms operate in. It should however be noted that not all the formal sector firms interviewed have premises of this standard and size, although all of them operate in premises that are far better than those in the Ngong' cluster.

None of the problems facing the informal sector clusters discussed above appears to be a major concern for the formal sector enterprises operating in Nairobi. For example, unlike the informal sector firms, the formal ones generally operate in areas officially demarcated for industrial activities in Nairobi; hence, they tend to have better power infrastructure than the informal sector firms. The challenges these firms face are the usual challenges affecting manufacturing in Kenya and developing countries in general, which were mentioned in Chapter 2. These challenges also affect the informal sector enterprises. Probably, the impact

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of these challenges may be worse for the informal sector enterprises than the formal sector enterprises, given the relatively high degree of haplessness, voicelessness and general lack of influence that characterise entrepreneurship in the informal sector.

Figure 5.6: Premises of a highly formal sector firm

Source: The picture was taken from the webpage of a formal sector firm

5.1.3 Trust and social relations

Interpersonal trust in a given social system may facilitate information transfer, knowledge sharing and transactions (Granovetter, 1985; Uzzi, 1997; Wu *et al.*, 2009; Hsu and Chang, 2014). However, I found interpersonal trust in Kenya to be low, particularly in Nairobi where cases of trickery, dupery and mugging are rampant. Usually, it takes a long time to gain someone's trust, and as a result, tribal/ethnic ties and longstanding acquaintances largely drive personal association and social relations. This is reflected in the difficulty I encountered

in gaining the trust of prospective respondents especially in the Gikomba cluster, which was a major challenge to my data collection exercise, as discussed earlier in Chapter 4.

Whereas I perceive the level of trust to be generally low, the Gikomba cluster appears to be the worst among all the clusters. Circles of social relations at Gikomba are largely made up of people of the same or close tribal backgrounds. For example, the Luos operate in their own circles, which are entirely different from those of the Kikuyus. These circles are used for providing social protection in the form of welfare benefits and initiatives, pooling and sharing of funds as well as production sharing. The operators in Gikomba believe in these "informal" circles more than the formal structures of the 'jual kali' associations as almost all of the operators I spoke with do not belong to any such association. They specifically mentioned lack of trust as the main challenge refraining them from participating effectively in jua kali associations. To flesh this out I recount what one of them said: "We don't trust each other but some people also envy others … everybody here is careful if you don't know the other person well, we always want to work with our tribe man" (Field work, 2012).

At Ngong', the operators are generally individualistic and assume a more capitalist posture and tribalism does not appear to drive any form of personal association. However, it appears lack of trust is one of the factors that drive the individualism and makes it difficult for them to be part of or establish a local wing of one of the jua kali associations in Kenya. Contrarily, the Kibuye cluster can boast of a relatively vibrant jua kali association, of which some of the operators of the furniture making firms are members. This may be the result of the relatively good degree of trust that exists among the operators in Kibuye cluster. A likely explanation for this degree of trust is that the operators at Kibuye are predominantly from the Luo tribe compared to the two clusters in Nairobi, which is much more cosmopolitan in nature with a relatively high incidence of fraudulent activities. The dominance of the Luos in the Kibuye cluster may arise from the fact that Kibuye is located in Kisumu, which is administrative capital of Western Province and constitutes the traditional land and home of the Luo people in Kenya.

5.2 Firm-level characteristics

The discussion on firm level characteristics deals with factors, which directly relate to the firm and its operations such as the firm's age, ownership structure, target markets and products. For firms operating in the same cluster, these characteristics can distinguish one from the other and may lead to different technology choices.

5.2.1 Age of firms

Table 5.1 presents the mean age of the firms. The table shows that the average age for all the firms (both formal and informal) is 12.8 years. However, there is a large difference between the average age of the informal sector firms and that for the formal sector firms. The table indicates that the formal sector firms have an average age of 31.4 years, which is over three times longer than the average for the informal sector firms (9.5 years). The average age of the informal sector firms compares well with the results of some recent studies. For example, Grimm *et al.* (2011) found an average age of 8.7 years for informal sector firms in Madagascar and Granstrom (2009) found nine years for those in Darkar. The figures from these studies were however estimated for informal sector firms in general and not for any specific industry or sector.

Table 5.1: Average age of firms by clusters/ sector

	Informal sector clusters			Informal sector	Formal sector	Total
	Ngong'	Gikomba	Kibuye			
Mean	7.8	12.0	10.3	9.5	31.4	12.8
Min	0.3	1.0	2.0	0.3	8.0	0.3
Max	20.0	29.0	28.0	29.0	70.0	70.0
Range	19.8	28.0	26.0	28.8	62.0	69.8

Source: Field data, 2012/2013

The distribution of the firms across different age categories provided in Table 5.2 further highlights the huge age difference between the informal sector firms and the formal sector firms. The distribution for the latter is skewed toward the older age groups with more than half of the firm (55%) having existed for over 29 years, none of them being less than five

years and only 5% of them fall within the 5-9 age bracket. Contrarily, the distribution of the informal sector firms is comparatively skewed towards the younger age brackets. Over twenty percent (22.5%) of the informal sector firms are less than five years and the majority of them (about 30%) fall within the 5-9 age group, followed by those within 10-14 years, which forms 26.1% of the informal sector firms. None of the informal sector firms has been in operation for more than 29 years and only 3.6% and 6.3% respectively fall into 25-29 and 20-24 age brackets.

A factor that may account for the large age difference between the formal and informal sector firms is the lack of continuity of the informal sector businesses beyond the life or retirement of the owners. That is, there is a high likelihood that an informal sector business will collapse when the owner dies or retires. Moreover, for some of the operators of the informal sector firms, particularly those who have been employed in the formal sector before, self-employment in this sector offers an opportunity to eke out a livelihood while waiting for greener opportunities in the formal sector (Field interview, 2012). Hence, such firms are likely to wind up when the owners or operators find better jobs in the formal sector. Another likely reason is the limited barrier to entry and exit due to relatively low capital and skill requirements needed to start an informal sector firm.

Table 5.2: Age groups of firms by cluster/sector in percentage (%)

Age groups	Informal sector clusters			Informal sector	Formal sector	All
	Ngong'	Gikomba	Kibuye			
0-4	24.5	20.0	21.2	22.5	0.0	19.1
5-9	35.9	20.0	27.3	29.7	5.0	26.0
10-14	26.4	24.0	27.3	26.1	15.0	24.4
15-19	11.3	16.0	9.1	11.7	5.0	10.7
20-24	1.9	12.0	9.1	6.3	10.0	6.9
25-29	0.0	8.0	6.1	3.6	10.0	4.6
> 29	0.0	0.0	0.0	0.0	55.0	8.4
Total	100	100	100	100	100	100

Source: Field data, 2012/2013

Within the informal sector, the average age also varies across the clusters. Table 5.1 indicates that the firms in Ngong' cluster (with an average age of 7.8 years) are younger than those in Kibuye and Gikomba clusters, whose average ages are 10.3 years and 12 years respectively. Further evidence is provided by maximum and minimum ages of the firms in the three clusters. While Ngong' has the youngest of all the informal sector firms (approximately four months old), Gikomba can boast of the oldest informal sector firm (29 years old), followed by Kibuye (28 years old). What may partly explain this variation is that my interaction with the operators of the firms in these different clusters showed that the Ngong' cluster sprang up recently, whereas the Gikomba and Kibuye clusters have been in existence since the early 1980s. Thus, given that most of the firms were born in the clusters in which they operate, firms in the Ngong' cluster on average should be younger than those in the other two clusters.

5.2.2 Ownership structure

Each of the firms including the formal sector ones fall into one of three ownership categories: partnership, family business or sole proprietorship. Table 5.3 reports the proportion of the firms that fall into each of these categories by cluster/sector. The table shows that the majority of the firms (71.8%) are sole proprietorships, followed by partnerships (16.8%) and then family-owned businesses (11.5%). Interestingly, a comparison of the distributions between the sectors shows an important difference between the formal and informal sector firms. As Table 5.3 indicates, sole proprietorships form about 85% of the informal sector firms while none of the formal sector firms is solely owned. The majority of the formal sector firms (70%) are family owned businesses compared to less than 1% for the informal sector firms while the proportion for partnerships (30%) within the formal sector is about twice that for the informal sector firms. Thus, contrary to ILO's (1972) belief that informal sector firms are more likely to be family-owned than formal ones, it has been found that many more of the supposedly formal sector firms studied in this research are family owned compared to the others.

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Table 5.3: Ownership structure by cluster/sector in percentages (%)

Nature of ownership	Informal sector clusters			Informal sector	Formal sector	All
	Ngong'	Gikomba	Kibuye			
Partnership	7.6	16.0	24.2	14.4	30.0	16.8
Family owned	0.0	4.0	0.0	0.9	70.0	11.5
Sole proprietorship	92.5	80.0	75.8	84.7	0.0	71.8
Total	100	100	100	100	100	100

Source: Field data, 2012/2013

Some differences in ownership structure also exist among firms across the informal sector clusters although such differences do not offset the high degree of similarities across the informal sector clusters. For example, Ngong' and Kibuye clusters do not have any family-owned businesses while just 4% of the firms in Gikomba are family businesses. Moreover, a large proportion of the firms across all the clusters are sole proprietorships although the proportion for Ngong' is higher than those for the other clusters particularly Kibuye. Table 5.3 indicates that 92.5% of the firms in Ngong cluster are sole proprietorships, with Gikomba following with 80% and Kibuye comes last with 75.8%. Conversely, Kibuye has the highest proportion for partnership (24.2%), followed by Gikomba and then Ngong' with 16% and 7.6% respectively. Kibuye having the highest proportion for partnership might have roots in the relatively high degree of trust that exists between operators in the Kibuye cluster.

5.2.3 Products, customer expectations and target market

The majority of the firms interviewed specialise in making wood furniture. Table 5.4 indicates that 68.7% of the firms produce only wood furniture while 29% produce wood furniture and metal furniture and/or combine wood and metal in their production. Less than 3% of the firms do only metal furniture. The table also shows that the informal sector firms in Gikomba and Kibuye clusters do not produce metal furniture at all and neither do they combine metal with wood to make any product. Contrarily, only 37.7% of the firms in the Ngong' cluster specialise in making only wood furniture and nearly 60% produce both wood and metal furniture or combine wood and metal to produce furniture items. Thus, the material

composition of furniture produced in the clusters is one of the significant differences between the firms operating in the Ngong' cluster and their counterparts in the other two clusters.

Table 5.4: Type of furniture by clusters/sector in percentages (%)

Type of furniture	Informal sector clusters			Informal sector	Formal sector	All
	Ngong'	Gikomba	Kibuye			
Wood only	37.7	100.0	100.0	70.3	60.0	68.7
Metal only	3.8	0.0	0.0	1.8	5.0	2.3
Wood and metal	58.5	0.0	0.0	27.9	35.0	29.0
Total	100	100	100	100	100	100

Source: Field data, 2012/2013

A unique feature of the informal sector clusters compared to the formal sector is that firms within a particular cluster produce a similar range of products with similar designs. This has given rise to cutthroat competition in these clusters, of which the respondents especially those in the Ngong' cluster cited as a major challenge to the growth of their businesses. Among the formal sector firms, the designs vary a lot and one of them indicated that his firm has legally recognised proprietary rights over some of its designs.

Interestingly, the Ngong' cluster appears similar to the formal sector firms in terms of material composition of their products. Table 5.4 shows that 5% of the formal sector firms produce only metal furniture compared to 3.8% for the Ngong' cluster. Proportionately, the formal sector firms that produce only wood furniture are about one and half times their counterparts in the Ngong' cluster while the reverse is true for the firms that produce both wood and metal furniture or combine these two materials in making furniture (Table 5.4). Thus, with respect to material composition of furniture, the firms in the Ngong' cluster appear similar to the formal sector firms while the firms in the other two informal sector clusters are similar to each other but different from the rest.

Another source of similarity between the firms in the Ngong' cluster and the formal sector firms relates to the proportion of their total furniture production for office use. Table 5.5 shows that for the firms in both Gikomba and Kibuye clusters, furniture for office purposes

constitutes less than 15% of their total furniture production (13.3% for Gikomba and 12.3% for Kibuye). The corresponding figure for the Ngong' cluster (31.4%) is more than twice the respective figures for Gikomba and Kibuye clusters while being relatively close to that for the formal sector firms (42%).

Table 5.5: Proportion (%) for office furniture in production

Cluster/ Sector	Type of product			All
	Wood only	Metal only	Metal & wood	
Ngong	29.3	22.5	33.4	31.4
Gikomba	13.3			13.3
Kibuye	12.3			12.3
Formal	27.9	80.0	60.7	42.0
Total	20.5	41.7	38.4	27.4

Source: Field data, 2012/2013

The type and quality of wood used for making the furniture in these clusters/sectors (which can be used as a gauge for product quality) provides another source of similarity or dissimilarity between the firms across the different clusters. There is a good degree of similarity between the Gikomba and Kibuye clusters on one hand, and between the Ngong' cluster and the formal sector firms on the other hand. At Kibuye, the wood normally used for furniture comes from Blue Gum, White Gum[19] and Cypress trees which are soft rather than hard wood. Almost the same can be said about the Gikomba cluster although there are few instance where the operators at Gikomba make use of hard wood from the Mahogany tree, which is almost two times more expensive than Blue Gum wood. Firms in the Ngong' cluster predominantly use Mahogany wood as in the case of the formal sector firms. The major difference between the formal sector firms and the Ngong' cluster in terms of quality of product is that the formal sector firms are able to achieve high quality joinery and finishing with more intricate designs, of which the operators at Ngong' cluster attribute to the relatively high quality and specialised machinery available in the formal sector firms.

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[19] Blue gum and white gum are common names for variants of Eucalyptus species.

Although demand and the degree of competition may be key factors that determine product price in these clusters/sectors, the differences in the quality of products seem to have greatly influenced price variation across the cluster/sectors. Products from the formal sector firms are the most expensive, followed by those from the Ngong' cluster and then the Gikomba cluster while Kibuye trails. For example, a seven-sitter, partially-stuffed, living-room chair, of which variants can be easily found in the three informal clusters, sells for at least Fifteen Thousand Kenya Shillings at Kibuye and for at least Twenty Five Thousand Shillings and Sixty Thousand Shillings at Gikomba and Ngong' respectively. The kind of sitting room chairs sold at the above prices in these clusters is hard to find in formal sector firms. The closest I found sells for about Two Hundred and Fifty Thousand Shillings. It should be noted that the firms in the informal sector cluster are able to make furniture items that are relatively more expensive than the figures produced above and so do the formal sector ones. However, customer demand is clustered in cheaper products.

Figure 5.7: Respondent's impression about customers' expectations and preferences
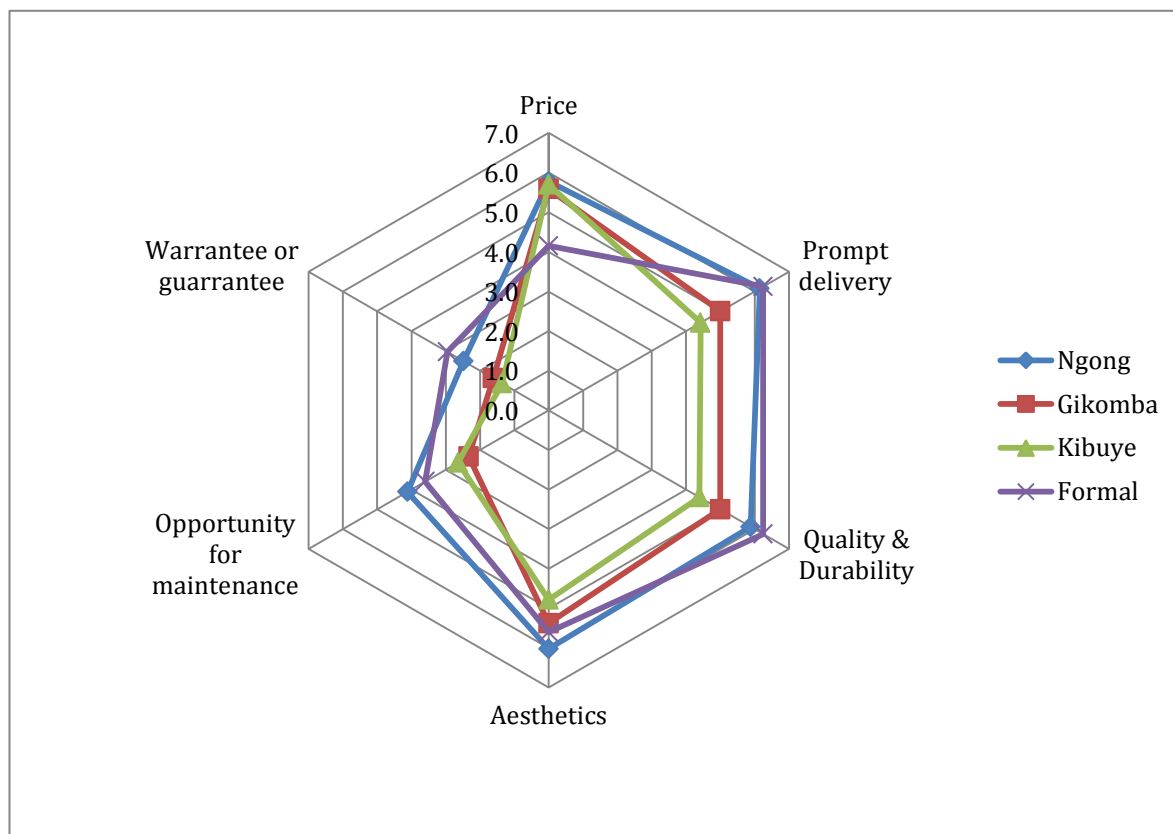
Source: Field data, 2012/2013

Unsurprisingly, the respondents' subjective judgment about their customers' expectations and/or preferences with regards to a number of factors shows that the customers of the formal sector firms place more importance on the quality of the products than customers of the informal sector clusters including the Ngong' cluster (Figure 5.7[20]). Figure 5.7 further shows that within the informal sector, the Kibuye cluster trails, with regards to quality and durability of the products, followed by Gikomba cluster and then Ngong' cluster. Correspondingly, the customers of the formal sector firms give the least consideration to product price compared to those of the informal sector firms.

From the foregoing discussion about product quality (and price) and when taking into account customer expectations (as perceived by the operators), one can conclude that, to a large extent, the formal and informal sector firms target or serve different segments of the furniture market in terms of income levels. While the formal sector firms mainly produce for the top end of the market (rich individuals and the corporate and public sector offices), the informal sector largely produce to meet the demand from low income categories of the population. A statement from a respondent in a formal sector firm which specialises in home furniture provide support for this argument: "We target home owners, that is, rich people….eh, for poor people they go to Gikomba market to buy their furniture. They just can't afford us" (Field interview, 2012). Interestingly, the very poor also can't afford furniture from the Ngong' cluster. An operator from this cluster noted: "People from Kibera[21] can't buy from here ... They don't come here and I think most of them who can afford household furniture must [will] go to Gikomba market" (Field interview, 2012).

It should be noted that market segments for the Ngong' cluster and the formal sector firms slightly overlap especially for the middle-income category of consumers. Given the relatively high quality of products produced in the Ngong' cluster and with a huge price difference between their products and those of the formal sector firms, they are able to attract

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[20] The figure presents factors that customers consider as important when buying furniture. On the Likert scale, the value of one (1) means customers do not consider the factor at all and seven (7) means that that factor is very important to customers.
[21] Kibera is the largest slum in Africa.

customers in the middle income category, of whom the majority may belong to the lower middle income group. During my stay at the Ngong' cluster, I found many instance where customers using their own private salon cars came to buy from these informal sector firms. The Ngong' cluster therefore poses some competitive threat to the formal sector firms with regards to market opportunities the middle income consumers provide. More evidence for this can be found in a statement by a respondent from a formal sector firm:

> "… we have been in business for a long time and we produce high quality furniture that compares well with those imported from Europe or Asia and so my prices are not friendly. Sometimes, people come here and they run away because of our prices. Then, they go and buy [something] from the Ngong' road which won't last and then later they come back to us" (Field interviews, 2012).

Thus, the firms in the Ngong' cluster to a large extent fit what Pieters *et al.* (2010) have described as "modern informal sector firms", which according to the authors, look like small and medium enterprises and can enter into competition with formal firms.

5.2.4 Linkages with other firms

Some of the informal sector firms are not directly involved in furniture manufacturing but have only invested in machines, which they use for rendering services to other operators in their respective clusters and surroundings. Henceforth, I will refer to these firms as 'machine-operator firms'. All such firms are found in the Gikomba and Kibuye clusters and they constitute about 22% of the informal sector firms (Table 5.6). Table 5.6 shows that 52% of the firms interviewed at Gikomba specialise in such services and such firms account for 33% of the firms in the Kibuye cluster whilst none is found in the Ngong' cluster. The Ngong' cluster however has the largest proportion of firms (about 38%, compared to 32% for Gikomba and 24% for Kibuye) that produce furniture and also provide machining services to other firms. Thus, the production processes in these informal sector clusters especially Gikomba and Kibuye (to lesser extent) are fragmented across different firms. In other words, division of labour across the firms is an important feature of production in these clusters unlike the other firms particularly the formal ones.

Table 5.6: Nature of manufacturing by clusters/sectors in percentages (%)

Nature of manufacturing	Informal sector clusters			Informal sector	Formal sector	All
	Ngong'	Gikomba	Kibuye			
Furniture only	62.3	16.0	42.4	46.0	100.0	54.2
Machine work only	0.0	52.0	33.3	21.6	0.0	18.3
Furniture and machine work	37.7	32.0	24.2	32.4	0.0	27.5
Total	100	100	100	100	100	100

Source: Field data, 2012/2013

Two main reasons account for this division of labour: First, some of the firms, which patronise the services of the machine operator firms, cannot mobilise resources to cover the high cost of mechanisation. Second, some of those firms do not find this investment economically viable even if they can organise resources for such investment. The latter explanation is consistent with literature on value chains, which suggests that firms specialise in order to take advantage of the relatively high efficiency of each other across the nodes in the production (value) chains (Gereffi *et al.* 2005; Kaplinsky and Morris, 2001; Gereffi, 1994). The value chain literature, however, does not explain fragmentation brought about by the resource gap that exists in firms that are unable to mobilise resources for investment in machinery. Thus, the motive for or the driver of specialisation in these clusters goes beyond the efficiency such specialisation can offer. I revisit this issue in Chapter 8 in the light of some of the literature on industrial clustering mentioned earlier and in the context of the firms' technology adoption decisions.

For the formal sector firms, all machines are for internal use only. Table 5.6 shows that none of the firms provide machining services to other firms. There is a relatively high degree of integration within these firms to the extent that a few of them have their own tree plantation to feed their furniture production (two of such firms took part in this study). Nevertheless, they obtain a very high proportion of their raw materials (e.g. wood, metal and fabrics) from other firms.

Moreover, the firms have weak linkages with foreign markets. None of them reported supplying furniture or components to any lead firm in foreign markets. For the informal sector, the firms generally do not have the capacity to export furniture. The firms in the Ngong' cluster noted that they occasionally get people they believe to be foreigners to purchase one or two items from them but they cannot tell whether they are for use in Kenya or overseas. According to the interviewees from the formal sector firms, the furniture industry in Kenya has an extremely small export market and the small proportion of their production, which lands on foreign soil, is never through their own initiatives. On rare occasions, they get orders from foreign customers (mostly from East Africa Sub-region) who usually take care of the shipment and even local transportation (from the workshop to the port) of the wares.

5.2.5 Nature of employment

While employment in the formal sector firms is relatively high (about 67 workers per firm on average), the number of employees per firm in the informal sector is low (Figure 5.8). Employment in the informal sector clusters is also largely casual, based on piece rate system of remuneration. Figure 5.8 indicates that the average number of employees (excluding the operators/owners) for the informal sector firms is 3.4 people. Of this number, 2.3 are casual workers and the remainder is for "permanent" workers. Only with reference to the informal sector firms, the word "permanent" is used here to describe casual but regular workers that have worked continuously for a firm for at least three months. While a few of those workers receive monthly wages, this is without pension benefits and an opportunity or motivation to join any kind of labour union.

For the formal sector, however, permanent employees refer to workers who hold appointment letters, have been enrolled in social security and insurance scheme, and are entitled to other benefits per the requirements of Kenya labour laws. The figure shows that on average each formal sector firms employs 52.8 permanent workers, compared to an average of 15.5 casuals, who are also paid based on the piece rate system. Moreover, unlike the informal sector, the permanent workers in the formal sector have attained relatively high

levels of education with some of them having completed university especially those in management, administrative and marketing positions.

Figure 5.8: Average number of employees by clusters/sectors

	Ngong	Gikomba	Kibuye	Informal sector	Formal sector	Total
■ Permanent	2.1	0.4	0.1	1.1	52.8	7.3
■ Casual	3.2	1.0	1.9	2.3	15.5	3.9
■ Total	5.3	1.3	2.0	3.4	66.8	13.1
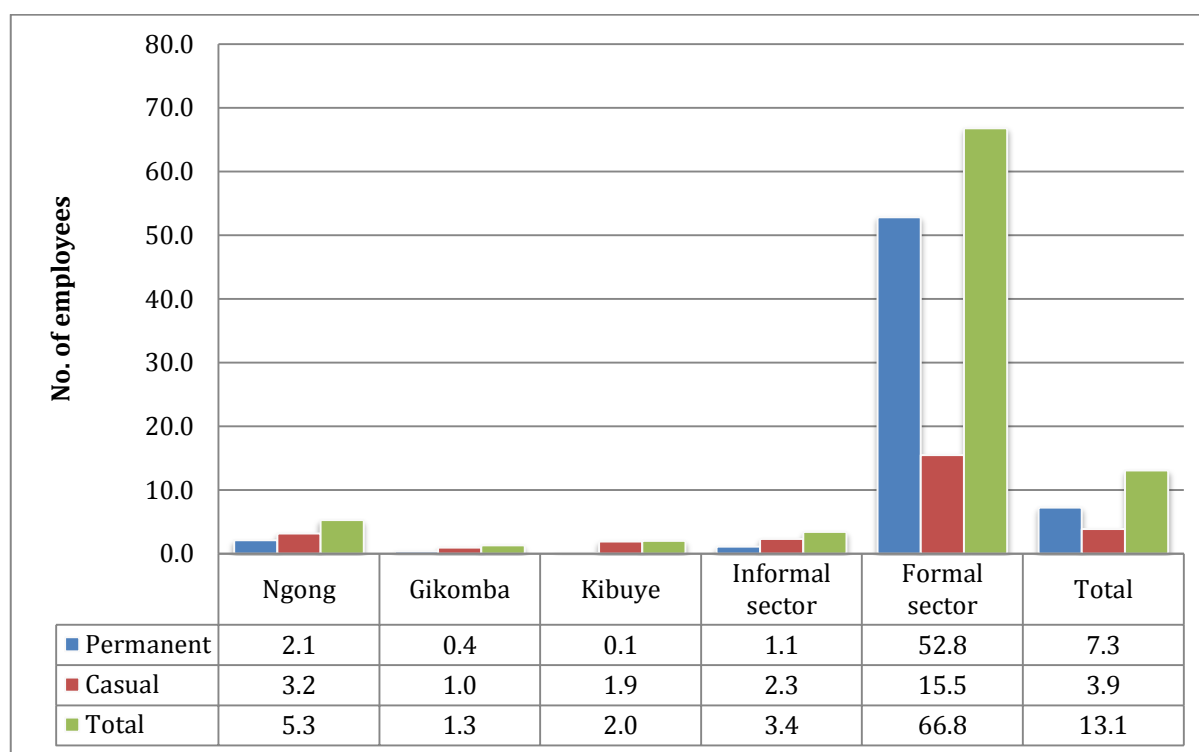
Source: Field data, 2012/2013

Table 5.7: Average number of employees by firms' age and sector/cluster

Age groups	Informal sector clusters			Informal sector	Formal sector	All
	Ngong'	Gikomba	Kibuye			
0-4	3.2	0.4	1.6	2.2		2.2
5-9	6.3	0.8	2.4	4.4	29.0	5.1
10-14	5.1	1.0	1.4	3.1	76.7	10.0
15-19	4.8	0.5	2.0	2.8	10.0	3.4
20-24	18.0	2.0	2.3	4.4	39.0	12.1
25-29		6.5	4.0	5.3	100.0	36.8
> 29					71.6	71.6
Total	5.3	1.3	2.0	3.4	66.8	13.1

Source: Field data, 2012/2013

Figure 5.8 also shows that employment per firm in the Ngong' cluster is higher than the corresponding numbers for Gikomba and Kibuye. These numbers provide evidence to

support the micro nature of informal sector enterprises that has been well articulated in the literature on informal sector. This finding is further reinforced by the numbers in Table 5.7 which shows that although informal sector firms below age five employ the least number of people among all the informal sectors clusters, the number of employees per firm in these clusters generally does not seem to increase with age.

2.5.6 Relationship with financial institutions

The nature of a firm's relationship with financial institutions can affect its operations including choice of technology, as noted in Chapter 3. Formal sector firms tend to have a relatively high degree of access to financial institutions compared to their informal counterparts. Figure 5.9 presents the proportion of the firms that have at least an account[22] with a bank or microfinance institution and the proportion that have applied for loan in the last two years from any of these sources. Needless to say, all the formal sector firms have accounts compared to 61% for the informal sector firms. Within the informal sector, the Ngong cluster recorded the highest proportion for firms with accounts (74%), and Gikomba and Kibuye follow in that order with 52% and 48.5% respectively. It should be noted that for the informal sector, the accounts are generally used for business as well personal purposes, unlike the formal sector firms which have accounts in the name of the businesses. Another difference between formal and informal sector firms is that while formal sector firms deal with formal banks, the informal sector firms normally do business with micro finance institutions particularly with respect loan acquisition.

The proportion of the firms which have applied for loans in the last two years varies greatly between the formal and informal sector firms. As shown in Figure 5.9, 50% of the formal sector firms interviewed applied for loans while just about 23% of informal sector firms made such applications. Within the informal sector, the Kibuye cluster recorded the lowest proportion (18%), followed by Gikomba (24%), and then Ngong' (26%).

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[22] The accounts referred to in this thesis do not include Mpesa accounts – mobile money account. The exclusion of Mpesa was the result of an oversight on the part of the researcher

Figure 5.9: Bank account and loan application status
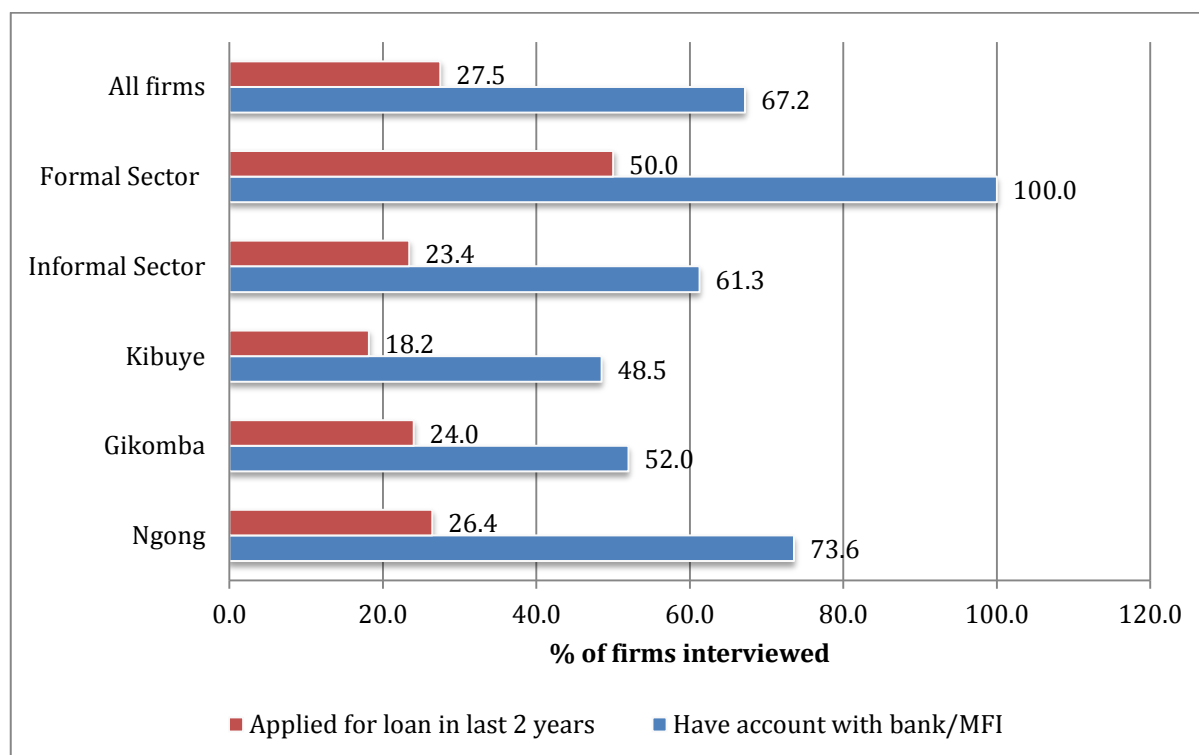
Source: Field data, 2012/2013

Table 5.8: Respondents' perception about their access to finance (% of firms in cluster)

Scale levels	Informal sector clusters			Informal sector	Formal	All firms
	Ngong	Gikomba	Kibuye			
1	26.4	48.0	51.5	38.7	0.0	32.8
2	17.0	20.0	18.2	18.0	10.0	16.8
3	26.4	20.0	12.1	20.7	25.0	21.4
4	24.5	8.0	12.1	17.1	30.0	19.1
5	5.7	4.0	6.1	5.4	15.0	6.9
6	0.0	0.0	0.0	0.0	15.0	2.3
7	0.0	0.0	0.0	0.0	5.0	0.8
Total	100	100	100	100	100	100

Source: Field data, 2012/2013

Based on the two indicators presented in Figure 5.9, one can conclude that firms in the Ngong' cluster have relatively better access to finance than the ones in Gikomba and Kibuye clusters, although their access is limited compared to the formal sector firms. This is confirmed by information provided in Table 5.8 about the respondents' perception about their

access to finance (using a Likert scale from one to seven, where one represents very limited access and seven represent very high access). Thus, comparatively the patterns in the table shows that formal sector firms have the best access, followed by the Ngong' cluster, Gikomba and Kibuye in that order.

5.3 Characteristics of entrepreneurs

This section discusses the characteristics of the owners/operators of the firms, which may influence the operations of the firm through their decision-making, determination, innovativeness and organisational skills.

5.3.1 Sex and age

The furniture making industry is a male-dominated sector. Table 5.9 shows that only seven out of the 131 firms interviewed are owned /operated by females. Three of the female firms are found in the Ngong' cluster, one in Gikomb and three are in Kibuye. Of the 20 formal firms, only one is a female-headed firm.

Table 5.9: Number (n) of owners by sex of owner and cluster/sector

Sex	Informal sector clusters			Informal sector	Formal sector	Total
	Ngong	Gikomba	Kibuye			
Male	50	24	31	105	19	124
Female	3	1	2	6	1	7
Total	53	25	33	111	20	131

Source: Field data, 2012/2013

With respect to age, the average for the informal sector generally does not vary across the clusters as shown in Figure 5.11. The average age of the owners of the informal sector firms is about 38 years compared to 58 years for the owners/operators of the formal sector firms, indicating a large difference between the average ages of the entrepreneurs across the two sectors. It is also important to note that while none of owners of the formal sector firms is below 35 years, about 42% of the owners of the informal sector firms are less than 35 years,

suggesting that the informal sector offers a platform for entrepreneurship among the youth in Kenya.

Figure 5.10: Average age of the owners by cluster/sector
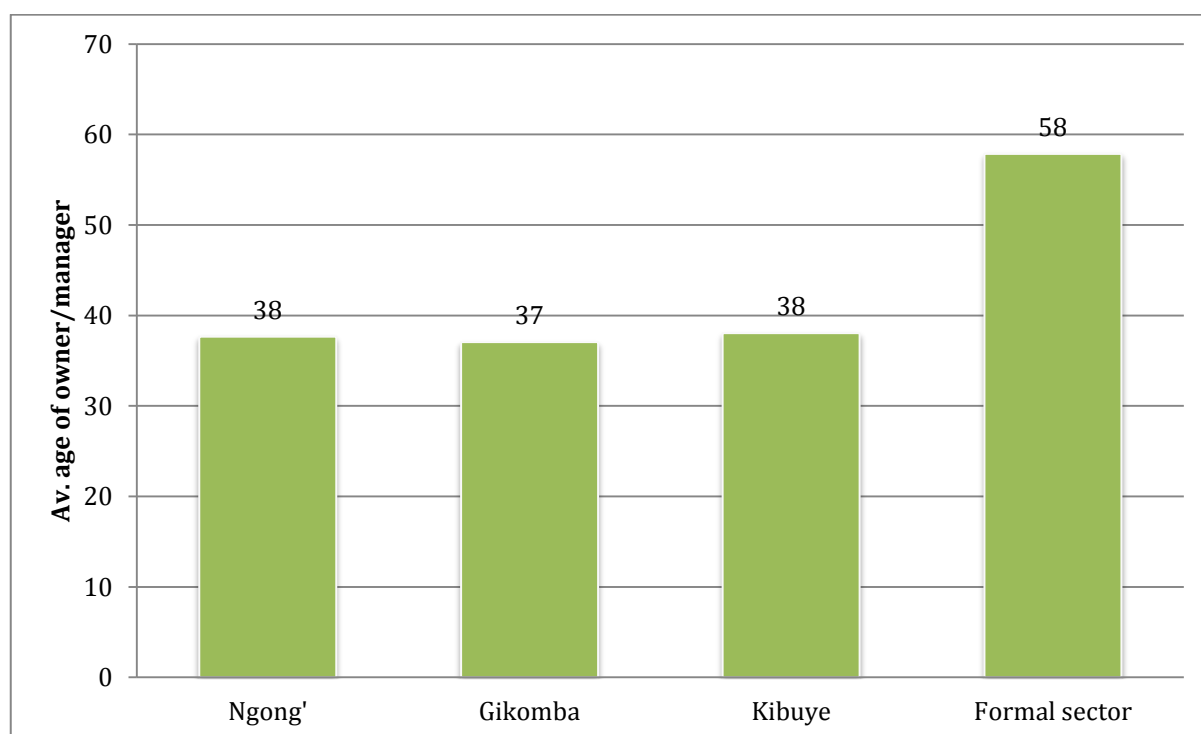
Source: Field data, 2012/2013

5.3.2 Educational background

Table 5.10: Level of education by clusters/sectors

Table Level of education	Informal sector clusters			Informal sector	Formal sector	All
	Ngong'	Gikomba	Kibuye			
Primary or basic	17	12	19	48	2	50
High school	17	11	11	39	6	45
Basic +poly	3	2	2	7	0	7
High school +poly	11	0	1	12	3	15
University	5	0	0	5	9	14
Total	53	25	33	111	20	131

Source: Field data, 2012/2013

The educational background of owners of the formal sector firms is much higher than those in the informal sector especially those in the Gikomba and Kibuye clusters (Table 5.10).

None of the operators in these two clusters have completed university while five people in the Ngong' cluster have completed university education. Generally, Table 5.10 shows that operators in the Ngong' cluster have better educational background than those in Gikomba and Kibuye.

5.3.3 Ethnicity

All the informal sector firms are owned and operated by indigenous Kenyans. In contrast, Indians who have naturalised in Kenya own and operate the majority of the formal sector firms. Figure 5.11 indicates that 65% of formal sector firms belong to these Indian Kenyans compared to 10% for indigenous Kenyans and 25% for people with other ethnic backgrounds. The Indian businesses are mainly family-owned, with family members occupying the top positions and a lot of indigenous Kenyans working on the production floor. While it is relatively rare to find an Indian working on the production floor, it is also relatively rare to find an indigenous Kenyan occupying a managerial position in these businesses.

Figure 5.11: Ethnic background of owners of formal sector firms
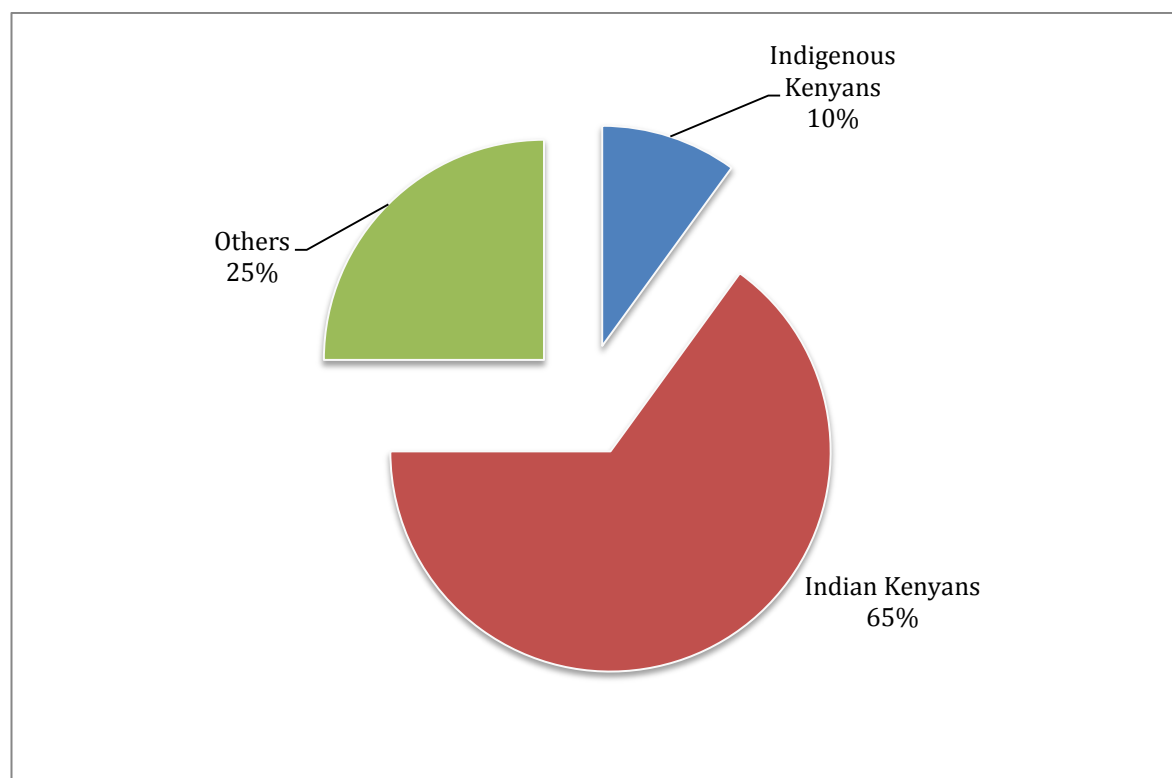
Source: Field data, 2012/2013

5.4 Conclusion

This chapter has presented a description of the firms and their operators in relation to the clusters in which they operate. The chapter began by discussing the business registration and tax obligation status of the firms, the nature of infrastructure/housing and social relations in the clusters. Other equally important factors such as the age of the firms, their ownership structure, products and target markets, linkages with other firms, employment by the firms and their operators' characteristics have been discussed.

An important conclusion from the discussion is that the firms I loosely referred to as formal sector firms are distinctive from the others operating in the Gikomba, Ngong and Kibuye clusters on almost all the characteristic indicators overviewed. However, the firms in the Ngong' cluster tend to exhibit (though to a limited extent) a few of the characteristics of the formal sector firms especially with respect to the middle income consumer's patronage for their products, the education level of the operators and their access to finance. Although the Ngong' cluster firms appear distinctive from the rest of informal sector firms, they are generally much more similar to those in Gikomba and Kibuye clusters than they are to the formal sector firms. Based on his personal interaction with some of the operators in the Ngong' cluster, Christopher Bull described them as "jua kali" in a foreword to Steve Daniels' book titled "Making Do", published in 2010. By and large, the discussions in the subsequent chapters of this thesis, thus, maintain the differentiation between the formal and informal sectors as purported at the beginning of this chapter.

It should however be noted that the findings in this chapter generally seem to lend credence to the structuralists' belief particularly that of Moser (1978) and Portes *et al.* (1989): They believe that informality is a continuum with varying degrees among firms. This view is contrary to the dualist's conceptualisation, discussed by Swaminathan (1991), which maintains a strict dichotomy. The discussion in this chapter suggests that the degree of informality is relatively high among firms operating in the Gikomba and Kibuye cluster, compared to those in the Ngong' cluster firms while it is relatively low among the firms I have

described as formal sector firms. The results also shed some light on the fact that the informal sector is heterogeneous as pointed out by Becker (2004) and other authors. This heterogeneity can occur even among firms in the same line of activity, as in the case of the furniture making firms studied in this research. Whether the between-firm, between-cluster and between-sector heterogeneities or differences are important for choice of technology and transfer mode will be a central element of the discussions in the subsequent chapters particularly Chapter 8. If such differences matter then the nature of technology choice in itself may also serve as a defining characteristic of informality as suggested by writers such as Joshi and Joshi (1976, cited in Swaminathan, 1991) and ILO (1972).

The next chapter examines the technical and economic characteristics of the technologies studied in this research.

CHAPTER 6 : TECHNICAL AND ECONOMIC CHARACTERISTICS OF THE TECHNOLOGIES

6.0 Introduction

This chapter discusses the technical and economic characteristics of the technologies. The discussion on the technical characteristics focuses on the functions of the machines, the run and physical characteristics such as size and capacity. The discussion on the economic characteristics examines factors such as the purchasing and maintenance costs of the machines, skill and infrastructure requirements for investing in the machines and the economic implications of some of the technical characteristics. Because some of the technical characteristics are closely linked to those that are economic, rather than neatly drawing a line between what is technical and what is economic the discussions on these broad themes are melded.

As argued in Chapters 3 and 4 which respectively discusses literature on technology choice and the conceptual framework for this study, the choice or adoption of a particular technology does not only depend on the factors relating to the decision maker (which have been extensively discussed in Chapter 5) but also the characteristics of the technologies. The aim of this chapter is to therefore provide information on the technical and economic characteristics of the technologies, which will enable a greater understanding of the firms' adoption or choice pattern between the three types of technologies, namely, Chinese machines, Kenyan machines and advanced country machines. (It should be noted here that the Kenyan technology refers to locally fabricated machines that are manufactured by artisans operating in the jua kali or informal sector). The discussions in this chapter will also help to identify the technology that may produce the desired development outcomes, particularly in the context of Kenya's development imperatives.

6.1 Functional description of machines

The discussions in this section are based on my field data and information from operating manuals of machines from Wadkin, an English manufacturer of woodworking machines/tools and Encyclopaedia Britannica. The section briefly describes the types of woodworking machines studied in this thesis. As indicated in Chapter 4, the commonest woodworking machines found in both the formal and informal sectors of Kenya's furniture making industry are the planer, band saw, saw bench and lathe. Other types of machines (e.g. panel saws, sanders, mortisers and binders), which are more complicated than the machines studied in this research, are also used in the formal sector but I could not find any of such complicated machines in the informal sector including the Ngong' cluster. Hence, the discussions in this chapter only focus on planers, band saws, saw benches and lathes from China, Kenya and advanced countries in order to allow for comparisons across the formal and informal sectors. Later in the Chapter, locally modified Chinese planers are distinguished from those that are not modified. Another distinction that will be discussed later is that between new and second hand advanced country machines.

6.1.1 Planer/Thicknesser

Figure 6.1 presents photographs of planing machines from the three different sources (China, Kenya and advanced countries). Panel A gives a typical example of the Chinese planing machine found in Kenya's furniture making industry while B is an advanced country machine (specifically, it is an English-made machine) and C is a locally-made planing machine. Strictly, the machines should be described as "multipurpose woodworking machines" because they can perform several functions such as planing (i.e. surfacing and/or thicknessing), ripping, crosscutting and sometimes other auxiliary functions such as boring and grinding. Although, they may perform several functions, surfacing and/or thicknessing are the main functions of these machines. (In order to simplify discourse around this type of machine it is henceforth referred to as "planer"). The subsections below describe the main functions of the planer in detail.

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Figure 6.1: Photographs of planers from the three sources of machines

a. Chinese planer

b. English planer

c. Kenyan planer

An appended saw bench

Source: Author's field photography, 2012

Planing (Surfacing and thicknessing)

Planing simply involves smoothing the surface of a piece of wood through the use of a tool or machine, herein referred to as planer. Depending on the flexibility of the functions of the planer, planing can be done in two main ways: surfacing and thicknessing. Surfacing involves placing the workpiece on the surfacing table – the smooth table-like surface of the planer which is visible in all the pictures in Figure 6.1 – and pushing the workpiece over the cutterblock (fixed at the indentation in middle of the surfacing table) which holds the cutter or tool. Driven by an electric motor, as the cutterblock rotates, the cutter removes the rough surface of the wood. For a long workpiece, two people are required to perform this function;

otherwise, one person may be enough. When two people are working, one person feeds the planer from one end of the table and other receives the workpiece at the other end.

In addition to the surfacing table, a planer must also have a thicknessing table before it can perform the thicknessing function. This table is set below the surfacing table and it is usually about half the length of the surfacing table. Unlike, the surfacing table the thicknessing table can be adjusted up or down within a range which varies depending on the make and size of the planer. This adjustment occurs through the use of a gearing system. It also has powered rollers which automatically pull the workpiece towards the cutterblock once the machine is fed. The main difference between surfacing and thicknessing is that the adjustable table in the thicknesser allows the operator to calibrate the machine to a given measure of the amount to be removed (i.e. the unwanted portion) and achieve a uniform thickness across the length and breadth of the workpiece, thus, the name "thicknesser". Another difference is that thicknessing is operationally and mechanically more complicated than surfacing since it involves relatively complex calibrations and relies on an elaborate mechanical functioning of the machine. However, like surfacing two people may be required to do thicknessing although there are relatively limited instances for thicknessing to be done by one person.

Ripping and crosscutting

Ripping and crosscutting functions of the planer are not different from the functions of saw benches. Hence, detailed discussion on these functions is therefore deferred to the sub-heading on saw benches. In fact, it is the same machine but has been slightly simplified and appended to the planer. In rare cases, this part of the machine may run on a separate motor, however, for almost all the machines studied it depended on the same motor as the planing part. All the three machines in Figure 6.1 have such appendages at the side of the surfacing table although that of the Kenyan machine appears more visible in the picture.

6.1.2 Band saw

Figure 6.2: Photographs of band saws from the three sources of machines

a. Chinese bandsaw

b. Adv. bandsaw

c. Kenya bandsaw

Source: Author's field photography, 2012

Figure 6.2 shows band saws from the three different sources. Panel A, B and C respectively shows examples of band saws from China, advanced countries and Kenya. The band saw is a type of sawing machine, but unlike a saw bench, the band saw is not used only to produce a straight cut in a workpiece, but more importantly, it is also used to cut wood into many different desired contours, that is, different patterns and designs which a saw bench cannot produce. As can be seen from all the three machines shown in Figure 6.2, it has a saw blade which is perpendicular to the working table, which is sometimes referred to as tilting table when the table is adjustable such that it allows mitred cut[23]. Sawing occurs when the workpiece is pushed against the cutting teeth of the saw blade, which is a continuous metal band driven by a drive wheel (powered by an electric motor) and an idler wheel. Almost all the band saws I found require only one person to operate but in the case of giant band saws which can be used for ripping heavy logs of wood, two people may be needed. (Giant band saws are not considered in the discussions in this chapter because they are rare in the furniture making sector, particularly the informal sector).

6.1.3 Saw bench

Also called circular saws, the saw benches are mainly used for ripping which is the process of cutting wood along its grain[24] but it can also be used for crosscutting which involves cutting wood across its grain. Figure 6.3 shows two saw benches. The picture in panel A is an advanced country saw bench and other is a Kenyan-made saw bench. No picture of a Chinese saw bench is provided in Figure 6.3 because I did not find a saw bench from China in any of the firms I visited although one of the respondents reported having owned a Chinese saw bench before. As can be seen from Figure 6.3, the saw bench has a working table or bench with a circular saw blade fixed in the middle of the bench. This saw blade can be adjusted up or down to fit the thickness of the workpiece. The blade is connected to an electric motor which turns the blade round. Ripping and crosscutting occur when the

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[23] It is a cut that allows two pieces of wood or other material to be joined together at an angle (usually 90 degrees) such that the line of junction bisects the angle.
[24] According to the Macmillan dictionary online, the grain of wood is defined as "the arrangement, pattern, or direction of fibres in …wood…"

workpiece is pushed against the saw blade with the appropriate side of the grain. For smaller workpiece, one person can perform any of the functions but when working on heavy workpiece two persons are always needed especially in the case of ripping.

Figure 6.3: Photographs of saw benches from Kenya and advanced country

a. Adv. circular saw   a. Kenya circular saw

Source: Author's field photography, 2012

6.1.4 Lathe machine

The Encyclopaedia Britannica online defines lathe as a "machine tool that performs turning operations in which unwanted material is removed from a workpiece rotated against a cutting tool". Figure 6.4 shows pictures of the lathe machines from the different sources. Panel A is the Chinese lathe machine, Panel B shows an example of advanced country lathe machine while Panel C shows a locally fabricated lathe machine. This machine is also power-driven by an electric motor, which connects to a rotating horizontal spindle. The workpiece is held between the two ends of the machine called the headstock which holds the horizontal spindle and the tailstock which can be moved or adjusted along the bed of the machine. The bed of the machine is the horizontal metal frame on which the headstock and the tailstock sit. During turning, a hand-held cutter is firmly positioned against the workpiece, with the cutter lying on a tool rest which may be adjustable along the bed. The non-adjustable tool rest normally takes the full length of the allowable space between the two ends, which are also called centres. This machine is used to turn a wood into cylindrical and cone-like shapes

which are sometimes variegated along the length of the workpiece. A careful look at the lower right corner of the picture in panel C of Figure 6.4 shows examples of finished workpiece from the Kenyan lathe machine. Unlike the other machines particularly the planer and the saw bench, the lathe machine always require only one person to operate it.

Figure 6.4: Photographs of lathe machines from the three sources of machines

a. Chinese lathe

b. Adv. Lathe
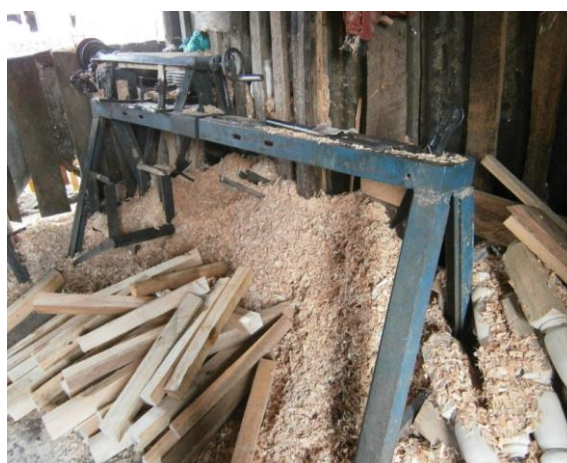
c. Kenya lathe

Source: Author's field photography, 2012

6.2 Durability and quality, purchasing and maintenance costs

This section discusses the purchasing cost, quality, durability and the daily run of the machines. The lifespan (actual life and expected life) of the machines are used as the indicator for durability. The actual life is the number of years a firm has had or used the machine while the expected life is the actual life of the machine plus any additional number of years the firm expect to use the machine before the machine is discarded or scrapped.

Also discussed in this section is the capital consumption (or investment) per annum for the technologies, which have been estimated, based on the expected life of the machines and the current purchasing cost.

6.2.1 Durability and quality

Table 6.1 presents the lifespan of the machines. Also in the table are the numbers of machines (N) studied for each type. These numbers roughly indicate the extent of penetration of the different sources for each type of machines, which is extensively discussed in Chapter 8. The table shows that the advanced county machines used in Kenya's furniture making industry are very old compared to those from the other two sources, particularly the Chinese machines. Most of the advanced country machines I found in the workshops of the furniture making firms in Kenya (particularly the four types of machines studied in this chapter) could be regarded as *vintage* machines. Popular brands I found include Wadkin, Robinson, Dominion, and Startrite. Some of these companies are no longer in existence. Information gathered from the Internet[25] shows that Robinson and Dominion have folded while Dalton Ltd acquired the financially distressed Wadkin in the early part of the 2000s (Dalton Ltd, 2013).

Table 6.1 indicates a huge age difference between the Chinese and the advanced country planers (especially those that were bought new). With an average of 4.2 years, the minimum number of years of use for the Chinese machines is one year and the maximum is 10 years. The corresponding average, minimum and maximum values for the advanced country planers which were new from factory when purchased are 35, 12 and 46 years respectively. Using the year in which the current users purchased the second hand machines[26] as the reference or starting year, the table further shows that the new Chinese planers are much younger than the used or second hand planers from advanced countries and the locally fabricated planer. The information provided on band saws, saw benches and lathe in Table

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[25]Brighouse Echo (2012) and http://www.woodmachinery.f9.co.uk/robinson.html (accessed on 26 July 2013)
[26] I use the term second hand machines to refer to all used machines irrespective of the number of times they have been passed down from one person to another between the first owner and the current owner.

6.1 reveals similar patterns with respect to the number of years they have been used by their current users although the differences between the various sources are most acute in the case of the planer.

Table 6.1: Number of years of use and lifespan of machines

Type of machine	Variable description	China	Kenya	Adv. (New)	Adv. (Used)
Planer	N	20	1	4	5
	Years of use:				
	Average	4.2	13	35	11.2
	Mini	1		12	2
	Max	10		46	27
	Av. expected life	10	15	36	29
Band saw	N	1	13	3	6
	Years of use:				
	Average	2	7	30	6
	Mini		1	10	1
	Max		22	41	14
	Av. expected life	10	16	37	26
Saw bench	N		7	3	4
	Years of use:				
	Average		4	30	6
	Mini		2	10	1
	Max		10	41	14
	Av. Expected life		13	34	25
Lathe	N	3	8	4	
	Years of use:				
	Average	3.7	6.6	32	
	Mini	1	1	10	
	Max	7	15	41	
	Av. Expected life	8	14	33	

Note: N represents number of machines studied for each category

These patterns in the number of years of use are reflected in the average expected life of the machines reported by the respondents. It should be noted that getting data on the expected life of machines from the respondents was tricky since the firms especially those in the informal sector hardly give up on their machines. As the machines deteriorate, they subject them to extensive repair to ensure their continuous use insofar as the person is unable to raise money to buy a new machine. The information provided on the average expected life is therefore based on the crude estimates reported by the respondents, which differ greatly

across the respondents mainly due to differences in their maintenance and handling culture. Moreover, respondents' whose machines are relatively new in terms of the date of purchase appeared to be more conservative on the estimates they provided than the others, particularly with respect to advanced country machines.

In spite of the above shortcomings, the data on expected life of the machines provide an insight into the differences in the lives of the machines from the three sources. While a brand new advanced country planer might last for 36 years if it was purchased new and 29 years if it was a second hand machine, as shown in Table 6.1, a brand new Chinese planer is expected to last for about 10 years, which is less than the expected life of the single planer from Kenya (15 years). Also, for the other machines, those from China have the lowest expected life, followed by those fabricated locally and then the advanced country machines. Thus, with respect to expected life, there are stark differences between advanced country machines and the other two sources and this is true for each type of the machines.

A major reason for the differences in the years of use and expected life of the machines is quality differences in the machines from the various sources. The quality differences do not only relate to the longevity or run of the machines but also important are factors such as functionality, particularly the precision and flexibility embedded in the functions of the machines, as discussed later in this subsection. Such quality differences might explain the differences in the number of years of use observed for the three sources and between the four types of machines. For example, the interviewees generally believe that the Chinese lathe machine is poorer in quality compared to the locally fabricated lathe whilst the Chinese planer is better than the locally fabricated planer, specifically in terms of functions such as surfacing and thicknessing (Field interviews, 2012). It should be noted here that if the quality differences were not real, the respondents would still report lower years of use and expected life for the Chinese machines, although, not to the extent reported. The reason is that the influx of Chinese machines into Kenya is a recent phenomenon which became relatively apparent in the early 2000s, with importation still surging year after year, as discussed in

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Chapter 1. The implication is that Chinese machines used in Kenya would be relatively new in terms of age even if their quality were comparable to those from advanced countries.

By the average expected life, it can be concluded that the advanced country machines are the most durable among the three types of technologies studied. A respondent from the informal sector confirms this in a statement with particular reference to machines from England: "England machines are the best, when you buy one, you can give it to your child and even your child can also give it to his child" (Field interview, 2012). All the respondents from both formal and informal sector firms noted that the advanced country machines last much longer than Chinese machines. According to them, the reason is that the machines from advanced countries, particularly England, are well constructed with good materials. This is evident in what a respondent who had invested in Chinese planer noted: "This one is not a perfect [machine], I bought it because I don't have the money to buy the best one [England-made machine]. Even if you buy the one from jua kali they last longer … but they don't give a good work like the China one". All the respondents from the informal sector made similar comments concerning the durability of Chinese machines, except two people with Chinese planers, of whom one said "… in terms of durability, the jua kali is not better than China but because they [jua kali machines] are cheap, we buy them and they are able to perform" (Field interview, 2012). The two however acknowledged that for band saws and lathe machines, those from Kenya last longer than those from China.

Further information on other aspects of quality (such as precision and flexibility of functions and run are discussed in the subsections that follow) provides more evidence about the differences between these three sources of machines used in the furniture making industry in Kenya.

Precision of functions/quality of work done

According to the Oxford Dictionary (online), precision in this context refers to technical refinement in producing measurements or specifications. Thus, in literal terms, it is the ability of a machine (for example a band saw) to exactly produce intended shapes or cuts baring

other factors relating to the operator of the machine, say his (or her) skills. This means that given the precision of the functions of a machine, the quality of work obtained from using the machines greatly depends on the technical knowledge of the operator, his agility and other personal attributes. The operator of the Kenyan surface planer in Panel A of Figure 6.1 provided evidence on this when he said:

> Whether you get a good finish from using the machines depend much on the operator because smoothness of the timber or workpiece depends on the way you fasten the blades there and if don't sharpen the blades well or it is protruding too much, then it does not produce smooth surface but if the blade comes out thinly then it can produce a smooth surface. So, that is what determines the smoothness and the roughness of the surface. So you can even have a thicknesser but [if] you don't know how to balance the blades then the output cannot be good. (Field interview, 2013)

He however agreed that a machine whose functions are highly precise always produce a major difference for an operator. Thus, in order to achieve good quality joinery and finishing, every carpenter would like to work with machines with high precision of functions.

However, as alluded to earlier, the machines from the three different sources do not have the same level of precision. Generally, the Kenyan machines have the least level of precision, followed by the Chinese machines. Between the Chinese and advanced countries machines, the difference in precision may not differ when the Chinese machines are new. However, whereas the precision of the functions of any machine may decline over time, the Chinese machines are known to deteriorate at a faster rate than the advanced country machines, according to an interviewee in the formal sector (Field interview, 2012). For the informal sector operators, however, the advanced country machines generally do not produce better quality output than the Chinese machines although one person admitted that advanced country machines may produce higher quality finish. These were his words: "In terms of precision the 'up country' [Europe] one can be said to be better than this [Chinese machine] but the difference is not much especially with experience person using the machine" (Field interview, 2012). It should be noted that the difference in opinions concerning the Chinese and advanced country machines may reflect the sensitivity of their customers to quality and consistency.

For Kenyan machines, their precision is comparatively low right from when they are new except the lathe machine, which according to the respondents is able to produce good quality work. A respondent with many years of experience in woodwork and who has been using both Chinese and Kenyan machines explained the low precision of the Kenyan machines as follows:

> For all jua kali machines, the material used is a malleable metal while the ones from Europe or China are from cast iron and you see cast materials are right more than other irons [materials], that means there is not much expansions occurring in the metal over time. But with these jua kali machines, because of the looseness of these joints, they easily knock the blades out of place. It is not easy for a jua kali to cast steel so they use plates and weld them together; that is not like the cast iron or steel. So in terms of the precision, you can't get it up to the level of China or England made machines. (Field interview, 2012)

A careful comparison between the Kenyan machines and the others, shown in Figures 6.1 to 6.4, particularly the planers, confirms what the respondent said. The bodies or frame of the Kenyan machines are constructed by welding patterned pieces of metal sheets and bars together while the frames for the others have been cast.

Another statement from a different respondent in the informal sector lays more emphasis on the extent to which Chinese machines are superior to the Kenyan machines with respect to precision:

> The Chinese machines have helped us a lot. You know when we used to work with these jua kali machines [only], the work we were doing were not accurate especially planing. When somebody brings you his timber, maybe six-by-one and you want to reduce it by half inch … the jua kali machines we used to plane it on the top [surfacing], and there was no gauge. So after planing, you will realise that it was not accurate, somewhere will be one inch, another half and another three-quarters [you won't get the same thickness across the length of the wood]. So with the introduction of these modern machines from China, our work has improved because it gives you what you want. And it makes the joinery and finishing work easier, you don't do a lot of hand planing and sanding; the smoothness is fine and our work has become faster because during those time it was slow, very much slow. (Field interview, 2012)

Flexibility of functions

According to Sethi and Sethi, "Machine flexibility refers to the various types of operations that the machine can perform without requiring a prohibitive effort in switching from one operation to another" (1990 p 298). High flexibility of woodworking machines may therefore be crucial because it permits a range of different cuts, shapes or patterns to be achieved with less

effort. Among the three sources of machines, the Kenyan machines especially the planers and (to a lesser extent) the band saws are the least preferred in terms of flexibility and the firms will choose a Chinese machine or an advanced country machine over the Kenyan machines, all things being equal. A comment from a respondent who uses a Kenyan band saw says much more:

> The problems with Chinese band saw is that of durability and the strength of the motor but it works better and it is more flexible because it has what we called tilting table which means you can cut a piece of wood at different degrees, say 45 degrees, 30 degrees etc., at the angle that you want. But you see this jua kali one cannot tilt, it is permanently flat. (Field interview, 2012)

Another comment from an operator of a Chinese planer is more instructive:

> …with this China machine, there is a lot of work that we can do which we couldn't do in those days. For example, the different designs and mouldings, it does so many things. It really helped us. During those days when we had only jua kali machines, people used to go to the Indians, they were the ones who had machines that could give different designs but nowadays we have this machine which can do same. (Field interviews, 2012)

The main reason cited for the Kenyan planer's limited flexibility is that usually they do not have the thicknessing unit, which is required for producing different designs. My interaction with the fabricators indicated that the thicknessing unit works with a more complicated mechanism, which they have not been able to master how to fabricate in the same way as they have with respect to the surfacing unit.

Daily run and robustness of machines

The daily run of a machine refers to how long a machine can be operated continuously in a day. Whether a machine has a long run or not depends on its robustness, that is, the construction and the strength of various parts/ materials used for the construction. With respect to run and robustness, there seem to be a large difference between the machines from the three sources: Chinese machines are reported to have very limited daily run compared to the advanced country machines and even the Kenyan machines. It should however be noted that although the interviewees provided a lot of insightful information about the run and robustness of the machines, they generally found it difficult to tell the actual run

of their machines because the nature of their production and/ or market demand rarely

necessitate continuous use of the machines throughout the day.

Box 6.1: Respondents' comments about the run of the planers

China planer

"You know it depends on the motor. If you have a high capacity motor, then it even work for 24 hours. Right now for me it does about three hours and it has to stop because it may overheat. You see, what I have is a Chinese motor but if I had an England motor of the same horse power, it could go for longer hours. After each three hours, I have to wait for about 30 minutes before starting again. So I only can operate for about seven to eight hours a day".

"It could work for only three hours continuously if I did not change the motor. Now, it can work from morning till evening if there is work without stopping. That is why I did the overhaul. If I did not do the overhaul it could work for three hours and you will have to stop for the motor cool for about 30 minutes to 1 hour, then you work for three hours then you stop again".

"It cannot work for one hour continuously because that motor cannot contain the amount of pressure…it cannot work for long hours like the England machines".

"I am able to operate for about six hours per day. But you have to stop for it rest half an hour after each two hours". "It work for about eight hours in a day but within the eight hours you will have to allow it to rest for about 30 minutes after every one hour".

"This planing machine before I changed [the motor], I could not even use continuously for an hour unless you plane for 20 minutes and then you wait for it to cool down. Now that I changed the motor, it can even work for five hours continuous".

"I think 6 hours is enough because if you use for long hours it can affect the motor; it will ruin the motor. Then within the six hours I will have to give it about 30 minutes to cool down after about every two hours".

"The Chinese machines, they cannot work in a mass production area because of their motors, their make… you find them they are not very strong … and we people sometimes we work at high rates…".

Advanced country planers

"This one of ours, it can work all the time without overheating. It can work on a whole lorry of timber. When it is overloaded, it goes off by itself; that is how it has been made to work".

"…this planer can work for four to five hours continuously without any problem. I haven't had any problem".

"This machine can work for 24 hours per day but you have to stop for it to cool for about 30 minutes to an hour. Within 24 hours, you will have to stop for about two times to allow the motor to cool down a bit. But it actually depends on the motor; if you have weak motor then you cannot operate it for long hours".

Jua kali

"…the motor on the jua kali planing machine is bigger than those from China. So the more you are using that one there is a time that the temperature starts rising after working for long hours. It has a fan to cool but this is normal for that machine after operating for long".

Box 6.1 provides illustrations of the comments from the respondents concerning planers from

the three sources. A glance through the comments shows that a Chinese planer can barely

operate continuously for three hours. Apart from resting throughout the night, it needs to rest

for at least 30 minutes after about one to three hours of work, allowing it to be used for a relatively limited number of hours per day. Contrarily, advanced country machines are believed to have a long run as indicated by the comments in box 6.1. Another comment from an owner and operator of an advanced country saw bench in the informal sector is more graphic:

> These machines you can operate for long hours up to about 24 hours without stopping. You will be tired and then you go and rest and come. If there is nothing wrong with anything [technical fault] you can go on and on for days. You will have to be changing the people; I can be there from the morning to about 6:00 pm and other person will come and take over and it goes on and on all through the night and another comes to continue in the morning. It could [still] be ok! (Field interview, 2012)

More interestingly, the respondents indicated that the Kenyan machines in general are able to operate for longer hours than those from China. One of them gave much clarity to this assertion by what he said about Kenyan saw bench:

> … if at all, it is made here in jua kali it is very strong than that one of the shop [China machine[27]]. What we do, we find a very powerful motor... Then we find some metals to make frames. When you make frames, now the motor is very strong so that the machine becomes very very strong. (Field interview, 2012)

A respondent from a formal sector firm also noted that "some of the jua kali machines can do wonders" and an anecdote from an informal sector operator who owns a Kenyan saw bench is more revealing:

> One day, a certain Zulu came here with two trucks of wood and wanted us to do the job before the next morning, it [the machine] ran from morning at 7:30 am to 10:00 pm at night. We worked from morning and I was only changing the workers. They would get tired and another would go and take over. So, it ran for about 15 hours continuously and we didn't have any problem so we could even touch to see if it [the motor] was hot, it had medium hotness any time we touched so we continued working. I believe it can even go beyond 15 hours if we have plenty of jobs. (Field interview, 2012)

The daily run of the machines depends strongly on the quality and size of the motor on it, as indicated in the first comment under Chinese planers in Box 6.1, although the functioning and toughness of other parts of the machines are also important. Thus, much of the difference in the run of the Chinese machines and the advanced country machines can be attributed to the quality and size of the motor on them. In fact, it is widely believed that an English motor

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[27] The Chinese machines are the commonly available machines on Kenya market and are displayed in the shops of the sales and distribution of firms of the machines.

of the same size (in terms of horse power) as a Chinese motor is stronger and faster than the Chinese motor. This may explain why the Kenyan machines also have higher run than the Chinese machines – most of the Kenyan machines are made with used motors from advanced countries, usually England. Of 15 respondents who were able to tell where the motor on their Kenyan machines came from, 13 were from advanced countries, of which English motors constituted about 60%, with one each from China and India respectively.

Caveats on the low quality of Chinese machines

Two main caveats must be mentioned with respect to the lower quality of Chinese machines found in Kenya's furniture making industry and the comparisons between the three sources of machines have to be hedged against these caveats. First, China is believed to produce products of different levels of quality depending on the target market. Products that go to the European and US markets are generally believed to have superior quality than products that enter markets in developing countries such as those in Sub Saharan Africa (Knowledge Wharton, 2012). Evidence from my field data confirms this belief: A formal sector operator who has invested in Chinese planer but had to change the chain of machine before using it said:

> … but this is not the best Chinese machine, maybe the poorest I have seen. The Chinese are also able to make good machines. I have seen some good machines from China which have been produced by indigenous Chinese companies, not even by transnational companies with manufacturing sites in China… I will consider those ones the next time I am investing in more machines. (Field interview, 2012)

Relatedly, an informal sector operator also had this to say:

> If we are doing a good job or heavy duty job we don't want those from China because those from China they are just like hobby machines. The Chinese did not make them to be used for commercial purpose… For example, you can use them for demonstration purposes in school where you show the children how the machines operate. Or a doctor can have machines at home so he can make furniture. So instead of buying those heavy duty machines, you can buy the hobby ones and they will do the job nicely. (Field interview, 2012)

He continued:

> … but we cannot blame China but people from our country, those people who import things for us to buy... Those people go to China to buy the cheap things to come and cheat us as if they are of high quality. Those are the people to be blame and they are our people. Look at those [road construction] machines used for constructing Thika

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Road[28]. They come from their country [China] and they are very strong. (Field interview, 2012)

After visiting many sales and distribution points, I found that the "hobby" Chinese machines are the most available on the Kenyan market.

The second caveat is that current or recent generation of machines whether from China or advanced countries are believed to be of inferior quality compared to the vintage machines. Hence, given that the advanced country machines used in Kenya's furniture making industry are much older than those from China, they will tend to possess higher desirable qualities particularly in terms of durability, run and robustness. An interview with a sales and distribution firm confirmed this as does the following comment from informal sector operator, who owns a very old band saw from one of the advanced countries:

> You can't make it for today; it is very strong, very good; nobody can… even Mzungu[29] they can't make it now because that will mean they will be killing their job. Because in those days, they made them to make their names forever; to be remembered forever. They were not making them because of money or whatever but your name. If at all, you are called Robinson you may still now be remembered. But for today, nobody can agree to do this high quality machines. (Field interview, 2012)

6.2.2 Purchasing cost and annual capital consumption per worker

Table 6.2 indicates the annual capital consumption per worker and the purchasing cost of the four machines from the three sources. Rather than relying on the historical data on acquisition cost, the current purchasing costs of the machines are used for the computations and comparisons. I obtained the current purchasing cost through a triangulation between data on perceived replacement cost of the machines from the manufacturing firms, prevailing market prices from marketing and distribution firms and the Internet. These sources helped to provide estimates about how much the machines would cost if they were to be purchased at time of the survey. This triangulation was done because the relevant decision making variable when choosing between different sources of machines is the amount the firm

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[28] Thika Road is an eight-lane super high way in Nairobi that has been recently constructed by a Chinese Company.
[29] Muzungu is a local terminology for Europeans.

perceive to incur on the basis of the prevailing internal and market information about cost at

the time of making such decisions.

Table 6.2: Purchasing cost, annual total and per worker capital consumption and labour input

Type of machines	Variable description	China	Kenya	Adv. (New)	Adv. (Used)
Planer	Current purchasing cost (USD)	1118	1000	11765	7647[+]
	Investment (capital consumption per year - USD)[**]	111.8	67	327	264
	Annual capital consumption/worker	55.9	33.5	163.5	132
	No. of workers required	2	2	2	2
Band saw	Current purchasing cost (USD)[*]	588	471	5765	2941
	Investment (capital consumption per year - USD)	59	29	156	113
	No. of workers required	1	1	1	1
Saw bench	Current purchasing cost (USD)		941	8824	4706
	Investment (capital consumption per year - USD)		72	260	188
	Annual capital consumption/worker		36	130	94
	No. of workers required		2	2	2
Lathe	Current purchasing cost (USD)	588	471	7647	
	Investment (capital consumption per year - USD)	74	34	232	
	No. of workers required	1	1	1	

+The value is for the price of a machine with 16-inch wide thicknesser while the corresponding values for the other sources are for planers with 12-inch thicknesser.
*The values are the current purchasing price of the small size band saw (about 400x500 mm table size.
**This is derived by assuming straight-line depreciation and with the lives of the machines as specified in Table 6.1.

For the four machines studied, large differences exist between the purchasing cost of

Chinese machines and those of the advanced country machines while Kenyan machines are

slightly cheaper than the Chinese machines. For example, a planer from England might cost

USD 11,765 in Kenya which is more than ten times what a Chinese machine of a similar size

might cost (USD1, 118), which is slightly higher than the cost of a Kenyan machine (USD 1,000) of a similar size (Table 6.2).

The Chinese machines are not only far cheaper than the advanced country machines but they also serve as viable alternatives to the Kenyan machines especially given that they tend to have a higher degree of precision and flexibility of functions than the Kenyan machines. This is evident in a statement by an informal sector operator, who has invested in a Chinese planer:

> This Chinese machine has really helped me and I cannot regret in any way having spent my money on it. This is the machine for the poor man or carpenter. The English ones are out of reach. An English machine of about this standard will go for about 600,000 [Kenyan] shillings and this is just around 80,000 [Kenyan] shillings so you see that much difference and I recommend other people to go for it and I will buy another one if I had the money. (Field interview, 2012)

Another person in the Ngong' cluster also said:

> The best for us is the second hand ones from England but they are very expensive... But when you start with the cheapest, you can go saving small, small until you get enough money to buy the best. So, I am hoping to buy the England second hand planing machine one day. (Field interview, 2012)

Thus, the cheap Chinese machines particularly the planer has been helpful to the informal sector operators who cannot afford second hand machines from advanced countries let alone the brand new.

However, for the other machines (that is, other than the planer), particularly saw bench and lathe, they seem to prefer the Kenyan machines to those from China. The main reasons are that they perceive the real value of the additional precision and flexibility the ones from China offer may not outweigh the additional investment cost, the cost associated with their relatively short lifespan and regular repair and maintenance, and other factors related to scale or capacity of the machines which are discussed later in this chapter.

Information on the annual capital consumption per worker (a loose measure of the capital labour ratio of the different machines or technologies, derived by dividing the acquisition cost by the expected life and the number of workers required for operating the machine) suggests

that the Kenyan machines employ the least capital per worker, followed by Chinese machines and then the advanced country machines. Detailed discussions on capital labour ratios and production coefficients are provided in Chapter 7. For now, it is enough to say that this data reinforces the fact that the amount of investment requirement for Chinese and Kenyan machines is much lower than that for advanced country machines. This is still true even when we take into account the large differences in the expected lifespans of the machines.

The cost advantage of second hand machines

The high cost of the new advanced country machines pushes some operators to invest in second hand machines which last longer than the Chinese and Kenyan machines. As indicated in Table 6.2, all the Chinese planers and the planer from Kenya were purchased new while less than half of the advanced country machines were new when purchased. Similarly, for band saws and saw benches, three of the nine machines and three of the seven machines from advanced countries were respectively bought new while all the machines from China and Kenya were new when purchased. For the lathe machines, however, all the machines from the three sources were bought new. Although these numbers may not be representative, they still tell a story about the important role second hand machines from advanced countries play in the industry.

This finding aligns with studies such as Castillo *et al.* (2012), Janischweski *et al.* (2003), Cooper *et al.* (1981b) and Pack (1981). In particular, Janischweski *et al.* (ibid) indicated the great extent to which developing countries depend on second hand machines by noting that over 100 billion US dollars of second machines and equipment are exported every year to developing and emerging economies. The study by Castillo *et al.* (ibid) investigated the relationship between second hand machines (and equipment) and technical efficiency in South Africa's industrial firms. They found that the use of second hand machines is positively associated with both economic and technical efficiency of the firms studied. Relatedly, the study by Cooper *et al.* (ibid) found that in comparison to new machines, second hand

spinning frames used in Kenya's jute industry were efficient and optimal in both social and private sense. They however noted that investment in second hand machines involves relatively high risk and uncertainties.

6.2.3 Maintenance and repair

Generally, the respondents indicated that the woodworking machines do not require a lot of maintenance and repair like automobiles. The major maintenance work on the planer, for example, involves rewinding the motor and repairing the cutterblock, of which motor rewinding tends to occur more frequently. For all the four types of machines, the motor is the part which frequently breaks down compared to the other parts. Being less robust the motors of the Chinese machines tend to break down more frequently than the motors on the advanced country and Kenyan machines. Table 6.3 provides information on the number of planers from the various sources whose motors have been rewound and /or replaced. It also shows the corresponding numbers for those that have never been rewound nor replaced. From the table, the motors for 11 of the 20 planers from China have been completely replaced compared to only one out of nine machines from advanced countries although the advanced country machines are much older than the Chinese planers.

Table 6.3: Motor breakdowns of planers

Sources	No. of planers	Rewound	Replaced	Rewound & replaced	Rewound or replaced	Neither rewound nor replaced
China	20	13	11	6	24	2
Adv.	9	6	1	1	7	3
Kenya	1	1			1	

Source: Field data, 2012

With regards to rewinding of motors, which mainly involves replacing the internal coils of copper wires, 13 and six respectively for the Chinese and advanced country machines have been rewound. These numbers translate into approximately equal proportions of the number

of machines reported for each source in Table 6.3 although most of the advanced country machines are many years older than the Chinese machines. The motor on the Kenyan planer which came from one of the advanced countries has also not been replaced although it has been rewound (but) only once after about 13 years of use. Rewinding becomes necessary when the coiling system in the motor burns mainly as a result of power fluctuations and overloading the machines (that is, running the machine continuously for too long and /or forcing the machine to accommodate a workpiece larger what it can normally accommodate.

Moreover, the rewinding of the motor on Chinese machines occurs much earlier in the life of the machine than the advanced country machines. For all the Chinese machines which have been rewound this happened in less than a year of use. For 10 of the 13 Chinese machines, the operators were able to report how long they used the machines before the first rewinding, of which the average is 4.6 months with minimum and maximum values of one and eight months respectively. The corresponding average figure for advanced country machines for which data were provided (that is, three of the six machines) is 34 months. In fact, this figure may underestimate how long a typical advanced country motor may last especially in the light of testimonies such as this one from a machine operator (an employee) of an advanced country planer in a formal sector firm: "Since the time I started working here from 1982 to now the motor of this machine has broken down only four times … it is a very good machine" (Field interview, 2012).

Other parts of the Chinese planer such as the cutterblock, gears, rollers, chains and bearings are also not as robust as those from advanced countries. For example, a formal sector operator who has invested in a Chinese planer noted that his machine came with a chain which never worked and had to be replaced before using the planer. This led him to make the following statement when I asked him about how the Chinese planer compares with the advanced country planer: "Don't compare the Chinese machine to the England machine; they are not comparable at all!" (Field interview, 2012).

Cost of maintenance and repair

The cost of rewinding a motor varies positively with the horse power and number of phases the machine has but does not differ across the different sources. Information from the repairers shows that rewinding a three horse power motor with three phases (i.e. the interface for electric input) costs about USD 58.82 while a five horse power with three phases costs about USD 94.12. Thus, for a given rewinding, the original motor on Chinese machines costs less than that on the advanced country machines although the Chinese motor have to be rewound more frequently over time.

Data on seven Chinese planers whose motors have been rewound show that on average they are rewound two to three times a year, while the corresponding average for four of the advanced country machines is less than one. In fact, the biennial average is still less than one. However, the high frequency of repairing Chinese machines still does not make investment in them less viable particularly for the informal sector firms. In support of this, one of them noted:

> … it is cheap and the England one is more expensive just that it needs more maintenance. But if you look at the cost of maintenance plus the purchase, it is still more economical than the England machine. So it is better to go for this one. I am comfortable with this planing machine and next time when I want to buy a planing machine of this type I will still buy the one from China. (Field interviews, 2012)

However, it appears that the respondent did not take in account the cost of the production downtime, in terms of the revenues that the firm is likely to lose, due to frequent breakdown of the motor or other parts of the Chinese machine. I do not have data on the cost associated with downtimes but there is a good reason to believe that such production losses, particularly for the informal sector firms, may be negligible. That is because they firms can rely on other firms providing machining services in their clusters while a machining service provider can refer his customers to trusted competitors, who may be less inclined to poach his customers during downtimes.

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6.3 Scale, infrastructure requirement, and modification of Chinese machines

6.3.1 Scale and infrastructure requirement of machines

Several studies such as Stewart (1982), Kaplinsky (1990), Majumdar and Vankataraman (1998) and Hall and Khan (2001) provide evidence supporting the importance of scale for investment decisions of firms. Tables 6.4 to 6.7 provide information on scale for the planer, band saw, lathe and saw bench respectively. Also shown in Table 6.4 is a distinction between unmodified/original Chinese planer and locally/jua kali modified Chinese planers, of which a detailed description is provided in subsection 6.3.2. Mainly relying on the horse power, the number of phases and the physical size, the tables indicate that on average the Chinese machines tend to have relatively low capacity or scale compared to the advanced country machines and even the Kenyan machines. For example, for all the measures presented in Table 6.4, those for the unmodified Chinese planers are much lower than those for the advanced country machines. The horse power of the motor on the Kenyan planer is also higher than the average for those on the unmodified Chinese planers. Typically, a Chinese planer has a 12-inch wide thicknessing table and one-phase motor with three horse powers compared to at least 16-inch wide thicknessing table, three-phase motor of about five and half horse powers for a typical advanced country planer.

Table 6.4: Scale/ capacity characteristics of planer

Variable description	Unmodified China	Modified China	Kenya	Adv. Country
Width of thicknesser (average in inches)+	12	12	12	18
Horse power (average)	3.1	4.4	5	6
Phases (average)	1.2	2.3	1	3.0
N	20	9	1	9

+The value for the Kenya machine is the likely size of a thicknesser it could accommodate if it were to have one. Size of the thicknesser is a proxy measure for the physical size of the planer.

In terms of physical size, the band saws found in Kenya generally vary greatly in sizes but particularly for those from advanced countries. The Chinese and Kenyan band saws I found are small and similar in sizes with an approximate tilting table of about 350mm by 335mm while those from advanced countries can go up to 750mm by 1000mm or beyond. With regards to the capacity of the motors, a comparison between Chinese band saw, Kenya band saw and those of similar sizes from advanced countries still shows that the Chinese band saw is relatively smaller in scale (Table 6.5). Table 6.5 shows only one Chinese band saw, making the above comparison somewhat tricky. However, my visit to a number of shops selling the Chinese band saws shows that the Chinese band saws typically come with a one-phase motor with horse powers between 0.75 and 1.1.

Table 6.5: Scale/ capacity characteristics of band saw

| Variable description | Small size | | | Medium size |
	China	Kenya	Adv.	Adv.
Horse power (average)	0.75	1.6	1.4	3
Phases (average)	1	1.5	2.6	3
N	1	13	5	4

Note: The small band saw's table size ranges from about 350x335 to 400x500mm while the medium size can be up to 750X1000mm.

Using the length of the lathe machines as a gauge for scale (the length of the machine determines the maximum length of workpiece the machine can accommodate), the Chinese lathe machines found in the furniture industry in Kenya are also of lower scale compared to the advanced country and the Kenyan lathes. Interestingly, the Kenyan lathes I found have the highest scale on average in terms of their length. Table 6.6 shows that the average length for Kenyan lathe machines is 6.9 feet compared to five feet and 3.2 feet for those from advanced countries and China respectively. All the respondents with Kenya lathe indicated that the Chinese lathe is too short for their work, with one of them saying: "…the Lathe machine from China has some disadvantages because of its short length" (Field interview, 2013). The length of the lathe varies positively with the capacity of the motors on them, as

shown in Table 6.6, which enhances the evidence for the relatively low scale of Chinese lathe machines compared to the others.

Table 6.7 compares the scale of Kenyan saw benches to those from advanced countries and indicates that there is not much difference between these two sources of machines when considering the capacity of their motors. The similarity is more pronounced with respect to the size of the table, which for both sources, approximately measure around 7800mm by 1050mm.

Table 6.6: Scale/ capacity characteristics of lathe

Variable description	China	Kenya	Adv.
Size (length in foot)			
Average	3.2	6.9	5
Min	2.5	5	3
Max	4	9	7
Horse power (average)	1	1.9	1.6
Phases (average)	1.0	1.3	2
N	3	8	4

Source: Field data, 2012/2013

Table 6.7: Scale/ capacity characteristics of saw bench[30]

Variable description	Kenya	Adv. (New)
Horse power (average)	5.6	6.3
Phases (average)	2.4	3.0
N	7	7

Source: Field data, 2012/2013

The horse power and phases of the motor is also indicative of the infrastructural requirement of the machines particularly with reference to electricity supply. The higher the horse power

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[30] Table 6.7 does not have information on Chinese saw bench because, as noted earlier, none of the firms interviewed was using Chinese saw bench at the time of the survey.

and phases the higher the electricity supply needed to power the machines. That means that advanced country machines do have higher infrastructural requirement than the Chinese machines but so do the Kenyan machines. This is because generally there is not much difference between the horse power and phases of the motors on the Kenyan and advanced country machines. Interestingly and as discussed in Chapter 2, power supply remains the greatest infrastructural challenge in Kenya (World Bank, 2010) although there has been some improvement in recent years[31].

6.3.2 Modification of Chinese machines – "Innovation over innovation"

It is difficult to deny the evidence that among the three sources considered, the Chinese machines have the shortest daily run, the shortest lifespan, the least robustness and the lowest scale. However, they are far cheaper than the advanced country machines but slightly more expensive and generally offer better precision and flexibility of functions than the Kenyan machines. Specifically for the planer, of which the advantages of those from China seem to outweigh the disadvantages, the operators particularly those in the informal sector prefer investing in the Chinese planers because they cannot afford the advanced country machines. But they are aware of its limitations particularly with regards to scale. The strategy they have adopted to benefit from the advantages of the Chinese planer is to modify or "re-engineer" some parts of the planer including extending the table used for ripping and crosscutting. Figure 6.5 is a picture of a modified Chinese planer and as can be observed, a clearly visible re-engineered feature is the extension of the ripping/crosscutting portion of the table, which appears whitish in the picture.

The re-engineering or modification also involves replacing some parts of the machine such as the bushes, switches and bearings, and most importantly the motor with those that are more robust, which in most cases are second hand from advanced countries. Table 6.4

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[31] The improvement in power supply mentioned is based on the author's experience of Kenya's power supply during two different visits. On the first visit which occurred in 2006, I spent 4 months in Kenya (Nairobi) during which power outage were highly frequent. The second visit was in 2012 to 2013 and I spent 7 months in Kenya (Nairobi and Kisumu); that was the period I used for collecting data for this study. I realised that the number of power outages had declined significantly on the second visit, an observation a lot of people in Kenya including my respondents attested to.

provides information on the capacity of nine modified Chinese planers, indicating that the average horse power of the motor on the modified Chinese planer is 4.4, with an average of 2.3 phases compared to 3.1 horse power and 1.2 phases for the unmodified machines. As evidenced in the second statement in Box 6.1, the informal sector operators refer to this process as "overhauling", which is done immediately or some few months after purchase. Thus, the "hobby machines" are customised (particularly with the aim of enhancing the scale) to suit the needs of the operators or to meet the requirement for commercial use.

Figure 6.5: An example of modified Chinese planers

An extended section of the table for ripping and crosscutting

Source: Author's field photography, 2012

However, there is a limit to the extent to which the machines can be modified. For example it cannot take a motor of more than 5.5 horse power. According to the respondents, when the motor is too large the small body of the machine cannot absorb the amount of vibration from the motor. Thus, according to the respondents, a more powerful motor makes the whole machine jerk to the extent that it negatively affects the quality of output.

A corollary following from the above discussion is this: If the Chinese machines are innovation for the poor, as one of the respondent asserted and quoted in subsection 6.2.2,

then the poor in Kenya are also doing further innovation on the machines. This innovation seems to take two forms rather than being uniform. The first is obvious and involves only the kind of overhauling or modification described above. The second however appears more subtle: What the firms do is that instead of overhauling, they deactivate the ripping/crosscutting function so that the work pressure on the machine is reduced and then invest in the Kenyan saw bench. This is an indication of a complementarity between investment in the Chinese and Kenyan machines. While the first type of innovation is most popular in Kibuye cluster, the second is more popular in the Ngong' and Gikomba clusters.

6.4 Skill requirement for operation and repair

Caselli and Coleman II (2001) and Kennickell and Kwast (1997) provide empirical evidence supporting the fact that the level of skills required to operate, maintain and repair a machine is important for anyone deciding to invest in a particular machine. Generally, for the four machines considered in this study which are used in the Kenya furniture making industry, the level of skill requirement for operating and repairing is low especially when compared to computerised and numerically controlled (CNC) machines. The skill requirement also does not differ greatly across the different sources.

The respondents noted that it is not difficult to find people with the relevant skills to operate the machines. Moreover, it takes a short time for someone to acquaint himself with how to execute the basic functions of the machines although they acknowledged that the advanced country machines are slightly more complicated. This is evident in a statement by one of them: "It is easy [to operate]! Even you, we can just go there right now and I will show you how to use it within a short period of time. It doesn't take too long to learn how to operate it. The only thing is that you should be very careful because they are sharp machines and it is rotating" (Field interview, 2012). Another person also had this to say:

> Almost all the machines are easy to operate. It takes a short time to learn how to operate them except for band saw and lathe which may take a bit more time. The band saw can take about a week to learn and maybe one month for the lathe but with any of the planing machines, even one or two days will be enough for some to learn how to operate it. ... because the work we normally do with the band saw and lathe are more technical. (Field interview, 2012)

Thus, the band saw and lathe require more time because they are used to make intricate designs, shapes and patterns.

It should however be noted that the Chinese machines need more care because they are less robust but it does not take a long time for someone to get acquainted with the needed precautionary measures. Moreover, the Chinese machines and more especially the Kenyan machines may require a good hands-on experience with them before one can achieve a comparable level of precision for the output as the advanced country machines. However, the advanced country machines, and to a relatively limited extent, the Chinese machines are more complicated because of the high degree of flexibility embodied in their functions, hence, requiring relatively higher expertise to operate them. However, these differences are more or less minor with regards to the demand they place on the machine operators and may even out between the different sources of the technologies. More importantly, my interactions with the operators did not show that such differences influence the choice between these sources of technologies.

Finding repairers is also not difficult particularly for the Kenyan machines since the fabricators are in Kenya and especially for the informal sector firms operating in the Gikomba clusters. Besides this furniture cluster is a cluster of metalworking artisans who fabricate the Kenyan machines and also do repair work on all other machines. For the other informal sector clusters and the formal sector firms, finding a repairer does not pose any worry though the repairers are not close to them as the firms in the Gikomba clusters.

Figure 6.6 is a picture of a jua kali repairer rewinding a broken motor for a band saw, indicating the availability of skills for repairing the machines in Kenya. This is also evident in a statement from an operator in the formal sector: "When it breaks, we look for engineers in town who repair it usually in a day" (Field interviews, 2012). In fact, for the Kenyan and Chinese machines, some of the operators who have long experience with woodworking machines said that they are able to fix some of the repair work easily by themselves. One of them however said that "The England planing machine is a bit complicated and for any little

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thing you will need the attention of a technician" (Fieldwork, 2012). Repairing the motor of the machines is however not simple, something the firms always outsource to technicians or electricians usually those operating in the informal sector, who reported that complications associated with rewinding motors do not differ across the different sources.

Figure 6.6: A repairer in Gikomba market fixing a broken motor

Source: Author's field photography, 2012

6.5 Availability of parts (usable and machine parts)

The availability of parts (both usable parts such as blades and machine parts such as the cutterblock and bearings) is important for investment decisions. All things being equal, it seems natural for firms to want to invest in machines for which they can easily find parts to replace those that are worn out. The availability of parts also makes repairers work easy and create demand for their services. For all the machines, irrespective of their source, finding usable parts does not seem to be a serious concern. Such parts are available on the Kenyan market and for the informal sector clusters there are always retailers of such parts operating within the clusters or in close vicinities. It however appears that finding usable parts for the advanced country machines in Kisumu where the Kibuye cluster is located is slightly difficult.

Unlike their counterparts in Nairobi, the respondents in Kisumu noted that it is sometimes a problem getting the usable parts of the advanced country machines. What may explain this is that Kisumu cannot boast of one formal sector furniture making firm while these firms are the main users of advanced country machines (as discussed in detail in Chapter 8) and might be the major source of demand for usable parts of the advanced country machines.

The big problem with the availability of parts has to do with machine parts, which is true for all the sources, perhaps except the Kenyan machines. The respondents indicated that some of the machines parts are difficult to get from the Kenyan market. For example, cutterblock and rollers of the planers are difficult to find on the local market. This is clarified by a statement from a respondent in the informal sector who has invested in a Chinese planer:

> If the part get lost, they are not easy to get but things like blades and belts [usable parts] you can find them. If something like the shaft [cutterblock] is broken, you can't get another original one to replace. What you can do is to send it to the jua kali engineers for them take the measurement and make one for you or go and buy a new machine. (Field interview, 2013)

Operators in the formal sector also rely on the local fabricators of machine parts as evidenced in the following comment from a respondent in a formal sector firm: "… whatever bearings or shaft that we require we have very good engineering workshops that are able to produce the items we need to replace; they are able to fabricate them here. Also, these are old machines; those agents who would sell parts are no longer there" (Field interview, 2012).

Replacing an expensive advanced country machine because spare parts are not available locally pushes some of the formal sector firms to directly source machine parts from dealers abroad, usually the machine's country of origin. On this, a respondent from a formal sector firm noted:

> At other times, we make contacts with the foreign suppliers through email, they give us quotations and if we can afford we buy and they send them direct to our factory. You know, these machines are very old, so when we get such problems we first try to find out if the manufacturers still exist or they have a sister company that can help us. (Field interview, 2012)

Importing machine parts is obviously not a good option for the informal sector firms because they may not have the financial capacity and general knowledge about how to do the

importation given that the educational level of the operators are generally low, as indicated in Chapter 5. This may be one of the reasons (but probably remote) why informal sector firms do not have effective demand for advanced country machines.

6.6 Conclusion

Focusing on the technical and economic characteristics of the machines, this chapter has identified many salient factors which may influence a firm's decision to invest in machines from the three sources. The chapter has shown that durability and quality of machines (precision and flexibility of functions, run and robustness) have a crucial influence on choice. In terms of these characteristics, the Chinese machines found in Kenya's furniture making industry to a great extent lag behind the advanced country machines and they are better than the Kenyan machine only in areas of precision and flexibility of the functions. However, the Chinese machines are far cheaper than the advanced country machines but slightly more expensive than the Kenyan machines, making them attractive to the informal sector firms particularly the planer. They perceive the Chinese planer offer a real net value over the Kenyan planer when the benefit of its precise and flexible functions is weighed against the extra purchasing and modification cost incurred when a firm invests in a Chinese planer instead of a Kenyan planer.

It has also been demonstrated that the scale of the Chinese machines found in Kenya's furniture making industry is the lowest among the three sources (followed by the Kenyan machines), a major reason for the modification of the Chinese planer. In terms of skill requirement and availability of parts, however, there seem not to be any major differences between the three sources of machines.

This next chapter examines in detail the output levels, productivity and factor intensities of the technologies, which provide an indication of their relative efficiency. Another issue for discussion is the returns on investment in the technologies from these sources. Also discussed are the transfer modes by which the technologies from the different sources reach the firms and the financing options available for the acquisition of the technologies.

CHAPTER 7 : FACTOR PRODUCTIVITIES, RETURNS ON INVESTMENT AND TRANSFER MODES

7.0 Introduction

In this chapter, the modes of transfer for the different technologies as well as the financing options for acquiring the technologies are examined and compared. Another central theme for discussion in the chapter, which precedes the discussion on transfer modes and the financing options, addresses factor productivities and the returns on investment in these technologies across the formal and informal sectors. The factor productivities, measured by the coefficients of production for the different technologies, help to illuminate the relative efficiency of the technologies and the degree of factor intensities embodied in them. The returns on investment, measured using two main indicators – net present value (NPV) and benefit cost ratio (BCR) – show the extent to which investment in these technology are profitable.

However, due to inadequacy of data on several variables (including the output levels of the different machines, output prices and other service inputs such as maintenance costs) needed for computing the indicators on returns for all the machines studied, the analysis on returns on investment only focuses on planers for illustration purposes and has been presented in the annex to this chapter. This is because gauging the output of the planer and other input variables was empirically less difficult to achieve compared to the other machines.

7.1 Production coefficients

The production coefficients are measures, which help determine the relative (technical) efficiency of the technologies as well as the level of their factor intensities. Three coefficients are estimated which are output-capital ratio, output-labour ratio and capital-labour ratio. The estimation of these coefficients requires having knowledge about the physical units of output the machines (planer) can produce within a given time period and the quantity of inputs

(labour and capital) used to achieve that production level. The labour input is measured in labour hours per year spent in producing a given level of output while the measure for capital is the annual capital consumption, which is derived by dividing the acquisition cost of the machines by their respective expected lifespans.

7.1.1 Measuring physical output

As alluded to introductory section of this chapter, gauging the output level of the planer was empirically tractable despite needing some restrictive assumptions while it was difficult to gauge the output levels of the other machines. The reason is that the other machines such as band saws and lathes are used for producing diverse products or designs, which place varying demands on the machines such that determining equivalent units for measuring total output of the machines was difficult.

The procedure for measuring the production levels of the planers begins with the number feet of a given timber (whether hard or soft wood) that can be planed in a day, given the daily run of the planers and assuming that the timber is six inches in breadth and one inch in thickness (i.e. 6x1). Across the formal and informal sector firms, the most common type of timber used for making furniture is the Mahogany tree, although as noted in Chapter 5, the use of Mahogany is much more common in the formal sector than in the informal sector. Per evidence presented in Chapter 6, I assume a daily run of six hours for Chinese planer, twelve hours and eight hours for those from advanced countries and Kenya respectively as the "rated operating capacity" levels. Although the respondents noted that the advanced country planer can operate for well over 12 hours, I assume that that is not realistically sustainable over a long period of time especially if the machine is expected to stay in operation for 36 years or more. In fact, the actual and expected lifespan of all the machines recorded in Chapter 6 may be determined by the actual daily demand-driven run of the machines which are well below the above-assumed rated capacity levels. Based on my daily field observation over the seven months of the data collection exercise the machines in both the formal and informal sectors on average may not be continuously operated for more than three hours per

day. Realistically, I therefore assume "actual daily run" of three hours for all three types of machines and for the two sectors, while allowing for differences in hourly production rates between the three types of machines. This provides a second scenario (i.e. actual daily run) for comparison with the ideal situation (i.e. rated capacity).

With regards to the number of feet of the 6X1 Mahogany timber that can be planed in a day, I did not get the opportunity to see any of the planers plane this kind of timber or any other type continuously for six hours. However, I got the chance to see the Chinese planer plane this type of wood for about 20 minutes, and the operator indicated that it may be able to do about 50 feet when it is operated continuously for an hour. This was consistent with my 20 minutes observation and implies that when it is operated for three hours per day it may be able to plane about 150 feet. I rely on the empirical data on the Chinese planer to determine the daily output levels for the other planers. Based on the horse power of the advanced country machines (six horse power) and the production rate of the Chinese planer, two scenarios are created for the advanced country machines – when it produces at one and half (1.50) times the rate of Chinese planer and when it operates at twice the rate of the Chinese planer. A scenario is also created for Kenya and the modified Chinese planer, that is, they operate at one and a third (1.33) times the rate of the original Chinese planer. All these assumptions lead to the total production levels for the various planers and scenarios presented in Table 7.1. The table presents two types of planers for China: the original/unmodified and modified planer. As was noted in Chapter 6, the modified planer is the original planer, which has been locally modified to suit the operating conditions of the firms.

Table 7.1: Production level of the planers per day

Type of planer	Assumption	Rated-capacity (hours per day)	Rated-capacity (feet per day)	Actual daily run (feet for 3 hours)
China	Original (unmodified)	6	300	150
	Modified China working at 1.33 times original China's rate	6	399	199.5
Advanced Country	Working at 1.5 times original China's rate	12	900	225
	Working at 2 times original China's rate	12	1200	300
Kenya	Working at 1.33 times original China's rate	8	532	199.5

The information on the output levels of the planers can help determine equivalent output levels for the other machines from the same source (i.e. China, advanced countries or Kenya) as a given planer, based on the relationship between the horse powers of the motor on the planer and those of the other machines from the same source as the planer. For example, the output level for the advanced country band saw is determined based the relationship between horse power of the motor on the band saw and that on the advanced country planer, given that the output level of the planer has already been determined. Thus, if the planer has a six horse power motor and can produce 1200 feet within 12 hours, then, the equivalent output for the saw bench, which has an average of 2.2 horse power motor and also operates for 12 hours, can be determined as follows: First, we determine the output level of a one horse power motor for advanced country machines by dividing 1200 feet by six, and second, we multiply the result from the first stage (which is 200 feet) by the horse power of the band saw (which is 2.2) to get the daily output level for the band saw when it operates for 12 hours. The same procedure is used for deriving equivalent units for the other machines and the results for the output per annum for the various machines are presented in the Table 7.2 and 7.3.

The rationale for the approach used for determining equivalent output levels for the other machines is derived from the analyses in Chapter 6 which suggest that for a particular technology source, say China, the characteristics of the machines such as quality, durability,

scale and functionality generally do not differ across the different types of machines (i.e. planer, band saw, lathe and saw bench). For instance, the extent to which an advanced country planer differs from the Chinese planer in terms of durability and scale (measured by the size of motor on them) is similar to that between Chinese band saw and advanced country band saw.

7.1.2 Interpretations of the production coefficients

Production coefficients can be generated for the two scenarios depicted in Table 7.1, which are production at rated capacity and production at actual (daily demand-driven) capacity utilisation. Table 7.2 therefore presents the coefficients when daily production is at rated capacity while Table 7.3 shows the coefficients for the case of the actual (daily demand-driven) production level. The tables do not present indicators for saw benches because there was no Chinese comparator for this category of machines, as was emphasised in Chapter 6. It should also be noted that the analysis or discussion in this subsection does not make any distinction between the formal and informal sectors since the same assumptions on the daily run of the machines are used for both sectors.

Four caveats are needed to qualify the coefficients presented in the tables. First, the annual capital consumptions for the machines are denominated in monetary units, based on the market values of the machines. This may introduce some bias given that the market value may not reflect the true economic value of the machines or capital because of price distortions associated with deviation of markets from their competitive equilibrium (Bhalla, 1985; Stewart, 1982).

Second, the labour used for operating the machines is taken to be homogenous across the formal and informal sectors. This is less problematic than the first caveat. The reason is that my interaction with the operators of the machines considered in this study in the formal and informal sectors did not reveal much difference in terms of their level of education except that those in the formal sector generally seem to have been in this vocation for a longer period of time.

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Table 7.2: Production coefficients for rated capacity operation of PLANERS, BAND SAWS

AND LATHES

Type of planer	Assumptions	Horse power	Output p.a. (feet)	Capital cons. p.a. (K) - USD	Labour hours p.a. (L)	O/K	O/L	K/L
PLANERS								
China	Original (unmodified)	3	90000	111.8	3600	805.01	25	0.03
	Modified China working at 1.33 times original China's rate	4.4	119700	147	3600	814.29	33.25	0.04
Advanced country	Working at 1.5 times original China's rate	6	270000	327	7200	825.69	37.5	0.05
	Working at 2 times original China's rate	6	360000	327	7200	1100.92	50	0.05
Kenya	Working at 1.33 times original China's rate	5	159600	67	4800	2382.09	33.25	0.01
BAND SAW								
China	Original (unmodified)	0.75	22500	59	1800	381.36	12.50	0.03
Advanced	Working at 1.5 times original China's rate	2.2	99000	156	3600	634.62	27.50	0.04
	Working at 2 times original China's rate	2.2	132000	156	3600	846.15	36.67	0.04
Kenya	Working at 1.33 times original China's rate	1.6	51072	29	2400	1761.10	21.28	0.01
LATHE								
China	Original (unmodified)	1	30000	74	1800	405.41	16.67	0.04
Advanced	Working at 1.5 times original China's rate	1.6	72000	232	3600	310.34	20.00	0.06
	Working at 2 times original China's rate	1.6	96000	232	3600	413.79	26.67	0.06
Kenya	Working at 1.33 times original China's rate	1.9	60648	34	2400	1783.76	25.27	0.01

Note: p.a. stands for 'per annum'

Third, the output measured in feet does not capture qualitative difference in the work done by the machines from the different sources especially the China and advanced country machines on one hand and the Kenyan machines on the other hand. As discussed in Chapter 6, the respondents noted that the quality of work done with the Chinese planer is comparable to that of the advanced country planer but better than the work done with the Kenyan planer. However, the output prices (the unit charge per a foot) do not seem to capture this difference: The owner of the single Kenyan planer I found charges the same

price as the others. Hence, the output prices could not be used to adjust the production levels to reflect the differences in the quality of work done with the different planers.

Table 7.3: Production coefficients for actual daily run (three hours) of PLANERS, BAND SAWS AND LATHES

Type of planer	Assumptions	Horse power	Output p.a. (feet)	Capital cons. p.a. (K) - USD	Labour hours p.a. (L)	O/K	O/L	K/L
PLANERS								
China	Original (unmodified)	3	45000	111.8	1800	402.5	25	0.06
	Modified China working at 1.33 times original China's rate	4.4	59850	147	1800	407.1	33.3	0.08
Advanced Country	Working at 1.5 times original China's rate	6	67500	327	1800	206.4	37.5	0.18
	Working at 2 times original China's rate	6	90000	327	1800	275.2	50	0.18
Kenya	Working at 1.33 times original China's rate	5	59850	67	1800	893.3	33.3	0.04
BAND SAW								
China	Original (unmodified)	0.75	11250	59	900	190.68	12.50	0.07
Advanced	Working at 1.5 times original China's rate	2.2	24750	156	900	158.65	27.50	0.17
	Working at 2 times original China's rate	2.2	33000	156	900	211.54	36.67	0.17
Kenya	Working at 1.33 times original China's rate	1.6	19152	29	900	660.41	21.28	0.03
LATHE								
China	Original (unmodified)	1	15000	74	900	202.70	16.67	0.08
Advanced	Working at 1.5 times original China's rate	1.6	18000	232	900	77.59	20.00	0.26
	Working at 2 times original China's rate	1.6	24000	232	900	103.45	26.67	0.26
Kenya	Working at 1.33 times original China's rate	1.9	22743	34	900	668.91	25.27	0.04

Note: p.a. stands for 'per annum'

The fourth is that the coefficients are limited because they have been estimated for an activity that is usually embedded in a broader production process. The estimates of output, capital and labour hours used for the computations pertain to the planing activity only. Thus, for example the capital-labour ratio is limited because the labour hours used for the estimation constitute only the working hours of the machine operators who work directly with the planer. In other words, it does not capture employment linkages with other segments of the production process. For example, it does not include other workers such as

management/sales staff whose employment may be linked to the type of technology the firm has adopted

In spite of the above caveats, the coefficients can be informative. The capital-labour ratio (K/L) is indicative of the level of factor intensities embodied in the technologies from the different sources. A relatively high capital-labour ratio for a particular technology indicates that that technology is relatively more capital intensive. That is, the amount of capital measured in US dollars required for each hour spent on operating the machine is higher compared to the other technologies, suggesting that that technology relatively offers less employment to people than to machines. The capital-labour ratios presented in the tables show that advanced country machines are more capital intensive than the Chinese machines while the Kenyan machines are the least capital intensive. This is true under the two main scenarios although the differences are more acute when capacity is underutilised with three-hour daily demand-driven run. For example, at this level of capacity utilisation, Table 7.3 shows that the capital-labour ratio of advanced country planer (0.18) is three times that of the Chinese planer (0.06), compared to 0.03 for Chinese planer and 0.05 for advanced country planer when operation is at rated capacity (Table 7.2). The tables also show that modifying (or overhauling) the Chinese planer, as described in Chapter 6, increases the capital component in production but not up to the level for the advanced country planers particularly when the daily capacity utilisation is at three hours.

While capital-labour ratio gauges the factor intensities, the output ratios (output-capital ratio (O/K) and output-labour ratio (O/L)) indicate the relative efficiency of the various technologies. If the machines were operating at the rated capacities, Table 7.2 shows that the Chinese planer, whether original or modified, is inefficient compared to the others particularly the Kenyan planer. They reported lower output-capital ratio and output-labour ratio than the other technologies. The relative efficiency between the advanced country planer and Kenyan planer is indeterminate: The Kenyan planer reported higher output-capital ratio while the advanced country planer reported higher output-labour ratios (Table 7.2). For both band saws and lathes, the Chinese machines are inefficient compared to the others

while the relationship between the advanced country machines and Kenyan machines are generally indeterminate.

However, at the actual daily production rate, Table 7.3 shows that the Chinese planer may be as efficient as the advanced country planer. Between these two technologies, the relative efficiency becomes indeterminate at the actual daily production rate. The Kenyan planer is still more efficient than the Chinese planer at the actual daily production level while its relationship with advanced country machine is indeterminate. For band saws, Table 7.3 shows that the advanced country machine and more especially the Kenyan machines are relatively more efficient than the Chinese machines at the demand-driven capacity utilisation. In the case of lathe machines, however, the relationship between the Chinese machine and the advanced country machine is indeterminate while the Kenyan machine is still superior to the Chinese machines in terms of efficiency suggested by the indicators.

The above analyses show that the level of capacity utilisation or the scale of operation of a firm has important implication for efficiency realisable from the different technologies particularly between Chinese and advanced country machines. The findings generally indicate that the advanced country technologies, which are more capital intensive, may have no advantage over the Chinese machines in terms of efficiency if we take into account the level of actual capacity utilisation. The Kenyan machine appears superior over the Chinese machines but it is important we do not lose sight of the fact that the Chinese machines produce better quality output and are more functionally flexible, and these two features have not been captured in the computations.

7.2 Returns on investment in the technologies

The annex to this chapter presents how profitability indicators – net present value (NPV) and benefit-cost ratio (BCR) – are derived for investment in planers for the different sources and across the formal and informal sectors. It is worth reiterating that these calculated indicators are largely illustrative of the kind of calculations that could have been done if the required data had been available. Hence, the present calculations are based on some restrictive

assumptions, which have been discussed in the chapter annex. Although these assumptions are based on my field observation rather being mere conjectures, the results derived from the analyses should be used with some caution particularly the policy implications thereof.

Detailed discussions of the results are also provided in the annex. However, the core findings from the analyses are summarised here as follows: The BCR indicates that the returns on investment in advanced country planers (and Kenyan planer) are better than Chinese planers at rated capacity utilisation for both formal and informal sector firms. However, the BCRs at actual capacity utilisation show that only the modified Chinese and Kenyan planers are profitable in the informal sector while all investments are viable in the formal sector with the modified Chinese planer yielding the greatest returns.

So far, the chapter has analysed the relative efficiency, factor intensities and the returns on investment in these technologies. However, while it may be worthwhile (in terms of profitability) to commit resources for investment in certain technologies, the accessibility to the modes by which the technologies are transferred and the nature of financing options for acquisition can limit the technology choice set for some of the firms. The discussions in the next section therefore turn to the transfer modes and the financing options that are available to the firms for acquiring the machines.

7.3 Transfer modes

As shown in Chapter 3, the literature provides many different means by which technology can be transferred from its place of origin to another, a process that depends on the nature of the technology, that is, whether it is a physical asset, a process, the technical knowledge of people or a combination of these. In this section, the mechanism by which the technologies studied in this research are transferred or diffuse to the firms in Kenya's furniture making industry is empirically examined and compared to those of the other technologies particularly the advanced country technology. As a reminder, the technology objects for the transfer or diffusion considered in this study are physical assets, that is, machines.

The transfer of the Chinese and advanced country technologies involves the movement of the technologies across international borders. For the Kenyan technology, however, the transfer involves the modes by which the technology moves from the workshops of the local fabricators to the furniture making firms. As noted in Chapter 3, the expectation is that the technologies studied in this thesis may be transferred through three broad channels: direct investment; network between firms (i.e. joint ventures and governed GVC channels); and arm's length market/trade.

7.3.1 Transfer mode for Chinese and advanced country machines

Characteristically and legally, FDI is a formal sector phenomenon; hence transfer of foreign technology to the informal sector firms in Kenya's furniture making industry is not expected to take place through direct investment. This study confirms this since, as indicated in Chapter 5, none of the informal sector firms interviewed has foreign ownership. The FDI component of investment in the formal sector also seems very limited. Of the 20 formal sector firms interviewed on the first round of interviews, only one involves direct investment with Turkish origin. This confirms a study by the United Nations Conference on Trade and Development (UNCTAD) (2005) which suggests that, unlike agro-processing, furniture making does not constitute a part of Kenya's manufacturing sector which is attractive to foreign investors. It is however interesting to note that the Turkish firm mentioned above has invested in Turkish machines which suggest that if I had found/interviewed a Chinese firm, there would have been a high likelihood that that firm would have some investment in Chinese machines. Generally, therefore, direct investment is not a major channel through which technologies from both China and advanced countries are transferred to the furniture making firms in Kenya.

Moreover, the field data indicate that governed GVC networks as well as joint venture do not serve as channels by which the technologies from both China and advanced countries are transferred to the firms operating in Kenya's furniture making industry. As mentioned in Chapter 5, Kenya's furniture making firms including the formal sector ones have an

insignificant export market and weak linkages with foreign firms. Thus, unlike the Kenya's tourism industry which has relatively strong connections with foreign firms in the tourism GVCs (Staritz and Reis, 2013), the firms in the furniture making industry are not integrated into the global furniture production or value chains, of which according to Kaplinsky *et al.* (2003) is mainly buyer-driven. Unsurprisingly, none of the firms interviewed had embarked on any investment in machines from China or any of the advanced countries based on an influence or initiative from a foreign or lead firm in the global furniture value chains.

Consequently, the firms including the formal sector ones obtain the technologies through arm's length market/trade, which involves purchasing the machines from the shelves of market traders. The trade arrangement is such that there is no or very limited relationship or contact between the manufacturer of the machinery and the firms in Kenya. All the firms interviewed in this study purchased their Chinese and advanced country machines through such arrangements.

The arm's length trade does not involve explicit and active transfer of any process technology associated with the machines. This is contrary to what would happen if, say, a multinational company were to transfer its technology to another firm in a foreign country. Technology transfer of the type seen in this hypothetical example would likely involve explicit licensing contract between the parties. Such agreement does not characterise purchasing machines from the shelves of market traders as in the case of the furniture making firms in Kenya. This finding generally supports a report by UNCTAD (2005) on Kenya which indicates that firms in Kenya have resorted less to foreign technology contracts with the local firms generally investing in technologies embodied in second hand equipment which (as noted in Chapter 6) is typical of the furniture making firms' investment in advanced country machines.

Table 7.4: Modes of acquisition of machines (planer, band saw, lathe and saw bench) used by the firms

Sources	Formal firms		Informal Firms	
	New machine	Used machine	New machine	Used machine
China	• Buy locally from traders (1)	-	• Buy locally from traders (19)	-
Kenya (Jua Kali)	• Buy directly from local fabricators (2)	-	• Buy directly from local fabricators (29)	-
Adv. countries	• Import directly from source through foreign agents (3)	• Import from source through foreign agents (3) • Buy locally from traders (2) • Buy from liquidating local formal firms (2) • Buy from local formal firms disposing old machines because they have invested in new or modern machines (3)	-	• Buy locally from traders (4) • Buy from liquidating formal firms (1) • Buy from government Technical training institutions through auction (1)

Note: The numbers in the brackets represent number of firms which have used the respective modes of acquisition

Source: Field data, 2012/13

Although the Chinese and advanced country machines broadly use the same entry channel into Kenya, the modes of acquisition used by the firms generally differ. Table 7.4 presents the different modes of acquisition used by the formal and informal sector firms for both Chinese and advanced country machines. In the table are also the numbers of firms that have used a particular mode of acquisition. The table was compiled based on the second round of interviews involving 41 firms, of which eight are formal sector firms. Five out of the eight formal firms were able to provide information on how the specific machines studied were purchased. It should also be noted that the different modes are not mutually exclusive to any given firm, that is, a firm may have used more than one mode of acquisition.

The table shows that all the Chinese machines including those purchased by the formal sector firms were bought from local traders who import from China. However, in addition to buying from local traders, there are other important modes of acquisition for second hand advanced country machines. These include buying directly from foreign agents, from liquidating formal sector firms, from local firms scrapping old machines for newer ones as well as from government technical training institutions. Purchasing from training institutions is however relatively rare. As indicated in the table, only one respondent reported purchasing machines, which were used in a government school but were being auctioned by the school. The data also shows that unlike the Chinese machines, which were all bought locally, the brand new machines from advanced countries for which information was available were imported directly from the advanced countries through foreign agents.

Also worth mentioning is an important difference in the modes of acquisition used by the formal sector firms and their informal sector counterparts. That is, the informal sector firms appear to rely exclusively on the local traders (or importers) while the formal sector firms are able to directly access foreign markets for both brand new and second hand advanced country machines. The likely explanation for this difference is that aside from the advanced country machines being unaffordable to the informal sector firms, these firms generally do

not have the financial, administrative and intellectual capacity to manage the relatively complex transactions associated with the importation of machines.

The inability of informal sector firms to directly source machines from abroad may partly explain why there appears to be only one mode of acquisition for Chinese machines as against the diverse means of acquisition for advanced country machines. As observed in Chapter 6, with Chinese machines selling at about a tenth of the price of advanced country machines, the informal sector firms find them highly affordable. The low cost has consequently created a relatively high effective demand for Chinese machines in Kenya especially among the informal sector firms. Since these firms cannot import by themselves, profit-seeking trading entrepreneurs are exploiting this opportunity by importing the Chinese machines.

However, effective demand for advanced country machines particularly the brand new ones is relatively limited because they are very expensive. Coupled with this is the fact that some of the formal sector firms may want to do their own importation, making the sales and distribution of the advanced country machines less attractive to the traders/importers. Consequently, availability of advanced country machines on the Kenyan market is relatively limited which in turn may also lead the formal sector firms to do their own importation.

Interviews with four sales and distribution firms of the machines in Kenya confirm the relationship between demand and the existence of specific modes of acquisition. The firms generally noted that furniture making machines have low turnover, compared to other equipment such as generators, compressors and agro machines and this problem is more acute with respect to machines from advanced countries. One of the firms, a veteran trader in furniture making machines, indicated that it diversified away from furniture making machines a decade ago because they offered low turnover. A respondent from another firm noted that his firm has almost moved away from selling furniture making machines, including those from China. In fact, there was not a single furniture making machine in the main shop at the time of the interview although he indicated that a few pieces might still be available in

other branches. For the other two firms, which still deal in furniture making machines, significant proportions of their wares including non-furniture making machines are imported from China. One of these two, a large firm employing 108 workers, imports about 90% of its machines from China. The other which does not directly engage in importation but only retails the machines had about 50% of its wares having been imported from China. The respondent from the retail firm, which has been in operation for 30 years, indicated that her company started with only Japanese machines but because they are relatively more expensive with low turnover they started diversifying into Chinese machines in the early part of the 2000s.

Another likely reason for the single mode of acquisition for the Chinese machines is a language barrier. Kenya is an English speaking country, which means doing business with Chinese who may not be able to speak English can be challenging. A respondent from one of the local traders (a sale and distribution firm) in Chinese machines interviewed confirmed this problem by noting that in order to overcome language problems, his firm has employed a Chinese agent in China who helps handle their transactions in China. The language barrier therefore makes direct sourcing of machines from China by the furniture making firms unattractive and more so for the informal ones. The reason is that the volume and the one-off nature of the firms' purchases may not warrant the cost associated with hiring or using the services of a Chinese broker or agent.

7.3.2 Mode of acquisition for Kenyan (jua kali) machines

Unlike the Chinese and advanced country machines, acquisition of locally made machines by the firms does not involve any form of cross-border transactions. More interestingly, the furniture making firms purchase directly from the fabricators, as indicated in Table 7.9, instead of market intermediaries (that is, sales and distribution firms) as in the case of Chinese and advanced country machines. The purchase, according to all the respondents in the second round of the survey who have invested in Kenyan machines including the formal

ones, involves placing an order with the fabricators before the machine is fabricated. (The terms for placing order from the fabricators are discussed in Section 7.3.3).

An important feature of the mode of acquisition for Kenyan machines is that the direct contact with the fabricators allows their customers to place orders for customised machines. This kind of customisation relates to the quality of materials and the robustness of imported parts such as the motor used for fabricating the machines. The room for customisation also allows for a high degree of price negotiation and reduction, which influences the quality and durability of the machines or at least some of its parts. I did not find this customisation or any of its kind as a feature of investment in machines from China and advanced countries.

However, like the Chinese and advanced country machines, arm's length trade arrangement characterise the mode of acquisition of the Kenyan machines used by the firms. While repeat purchases from a fabricator are not ruled out, the firms buy from any fabricator they can trust.

7.3.3 Payment terms and financing

The payment terms available for the acquisition of machines, if they differ across the sources of machines, may influence investment decision between machines from the different sources. In this section I discuss the payment terms and also how the firms finance the acquisition of the machines, that is, whether from internal sources or through bank loans.

<u>Terms of payment for machines</u>

Generally, two main terms of payments exist: The first is "cash and carry" which is more popular and involves making outright payment of the total cost of the machines before being allowed to move the machine away. The second is a flexible system where the firms are allowed to make a deposit and then to pay the remaining balance in instalments over a short period of time, usually three months. Purchasing Chinese and advanced country machines mainly involves the former approach while a handful (i.e. four of the informal sector firms interviewed in the second round of the survey) reported having used the latter for purchasing Kenyan machines.

Generally, placing an order for a Kenyan machine, whether customised or not, involves paying an initial deposit, which based on negotiation may vary from 30% to 65% of the full cost of the machine. The remaining balance is cleared when the machine is ready for delivery but in the instances of flexible payment approach, the remaining balance is spread over an agreed period of time. The availability of such a facility is however based on personal and trust relations between the buyer and the fabricator, which as noted in Chapter 5, is largely driven by tribal ties especially in the informal sector and particularly in the Gikomba cluster.

With limited access or resort to external financing, as discussed in the next subsection, the flexible payment approach appears valuable to the informal sector firms. In an attempt to boost sales, some of the local traders of the Chinese machines have tried this approach but not without failure: Two of the four traders interviewed indicated that they tried this approach but it did not work well for them because of abuse of trust by their customers, pushing them to resort to only the "cash and carry" method.

Financing options for investment in machines

One of the challenges to doing business in Kenya is access to finance especially from formal financial institutions which is more acute in the case of informal sector firms (Bowen *et al.*, 2009; Atieno; 2009; Obeng *et al.*, 2012). Atieno (ibid) specifically noted that most of formal financial institutions do not lend themselves to doing business with micro and small scale enterprises. Obeng *et al.* (ibid) studied the Sokoban informal woodworking cluster in Ghana and found that the lack of access to finance is one of the major challenges facing artisans in this cluster. The field interviews with informal sector furniture making firms also confirm this as can be seen in the following statement from one of the operators:

> I don't have the capacity to borrow from the bank. Moreover, my friend, the bank cannot loan you when you are operating in a structure like this. Where is the security of the money they want to give you? Banks consider a lot, so many things, before giving a loan. After looking at your savings, they also ask for collateral and inspect your workshop. They will come here and find that this workshop is a debris. They want someone operating in permanent building so that they are assured that if they help to invest in machines or any other thing, it won't be destroyed by sun, rain or fire until you have fully recoup the investment. So, it is not easy for us to get financial help

from banks. If someone will come here today and offer us machines, I tell you we can do wonders. (Field interview, 2012)

For a lot of the firms, perceived and/or real lack of access to bank financing leaves them with few alternatives for financing machine acquisition such as savings (i.e., internal financing), microfinance loans, and financial support from relatives. The commonest among these alternatives is, however, savings or internal financing which appears popular not only for the informal sector firms but also for the formal sector firms. Of the 33 informal sector firms interviewed in the second round of the survey, almost all had purchased a machine with savings while few (seven of the 33) had purchased machines with loans, mainly from microfinance companies. Two of these firms that had purchased machines with loan actually borrowed to top up savings, meaning the machines were not entirely purchased with loans.

Specifically for the informal sector, savings are sometimes organised through what has been referred to in the literature as rotating savings and credit associations (ROSCA) (e.g. Ardener, 1964; Bouman and Harteveld, 1976; Shanmugam, 1989; Hevener, 2006). ROSCA is a system where a group of informal sector operators save together and give their total savings at the end of a given period (say, a month) to one of the members. The process is repeated until all the members in the groups have had their turn. Three of the firms interviewed had raised money to buy machines through ROSCA.

For the eight formal sector firms interviewed on the second round of survey, data obtained on how they finance machine acquisition was less adequate. The main reason for this is that the machines these firms have were purchased many years ago and people who are now in charge of the companies' operation or management (i.e. the respondents) could not provide information about how the acquisition was financed. Four of the eight firms were able to provide information although the information was relatively less detailed. Two of the four, which were able to provide information, had purchased machines using bank loans although these firms tend to depend on internal financing as well. This finding aligns with that of Banda (2013) who studied pharmaceutical companies in Zimbabwe and found that the firms tend to rely mostly on internal funds for investment in machinery and equipment. Though the

industry Banda studied may be very different from what this thesis focuses on, the findings of these two studies highlight the limited financing options available to firms operating in developing countries.

Aside from the lack of access to external financing because firms are not able to meet the requirement of the financial institutions, internal financing or savings appears more attractive for two more reasons: First, the firms find the interest rates charged on the loans to be high especially in terms of effective rate of interest[32] charged, particularly loans from microfinance companies. That means that the opportunity cost of using savings (that is, interest forgone) is lower than the cost of borrowing given that interest rates or earnings on savings are lower than the interest rate on loans. More worrying is that for the informal sector firms the loans obtainable from microfinance companies have virtually no grace period. A respondent explained why he does not want loans as follows:

> Well, well, well … you see with us around here we are very careful. We don't go for loans easily because we have seen so many businesses flopping because of loans … I have never tried going for loan. No, no ... I don't, I don't. It has never been an option for me. I have seen so many people around, like there is one guy who is our friend, an old friend but he depended on the very loans. Now they came back and they auctioned everything he owned and he went home [to the village]. It was very sad. The microfinance come around to us but whatever the interest they are looking for is too much. If somebody will give 10,000 Shillings, he will give you a grace period of say one month and then you start paying back. Now, if you sit down to calculate the amount of money you will pay back, you will find that you will be paying back 12,500 Shillings or even 15,000 Shillings. So we simply depend on our daily savings on our sales. (Field interview, 2013)

Another person had this to say: "You know, we normally fear [loans] because you don't know whether you are going to get a lot of jobs after getting the loan so you can pay the loan back … each and every month you to have sign how much you will be giving them" (Field interview, 2013).

Another person who had invested in a Chinese planer with a loan from a microfinance company described how he copes with the conditions on loans from microfinance institutions including the repayment terms as follows:

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[32] This is the simple interest rate that produces the same amount of interest as the compound interest rate.

For thicknesser, I bought just a year ago through loan because before buying the machine I sat down and realise the maximum revenue I can get from a machine in a day. After realising how much I get from the machine in a day, I had to stick to my budget knowing that I will be able to raise the amount I have to pay at end of every week ... As I speak with you I should be going to pay loan now. In fact, I am already delayed that is why I was telling you I can only have 30 minutes with you. (Field interview, 2013)

Second, the firms generally do not buy all the machines at a go but they purchased one after the other reducing the need for external financing or allowing them to depend on their savings. In relation to this, a respondent from a formal sector firm indicated: "I raised funds for purchasing machine out of my savings/sales. I have never borrowed money from banks for machines. This is because I have never bought a lot of machine at once; I normally buy one after the other as we continue the business" (Field interview, 2012).

7.4 Conclusion

This chapter has focused on the mode of transfer of the three technologies to the firms, financing options for machine acquisition, factor intensity and relative efficiency of the technologies as well as the return on (or profitability of) investment in the technologies. Of the modes of transfer identified in the literature, the study has found that the most common for the firms is arm's length trade. For the informal sector, this seems to be a truism as they lack the capacity to engage in any other transfer method such as joint venture. Moreover, no foreign direct investment could possibly go to the informal sector and they also do not participate in the furniture global value chains (GVCs). The formal sector firms also do not have any meaningful participation in GVCs and only one of the 20 formal firms interviewed in the first round of the survey can be classified as a foreign direct investment while no joint venture was found.

The firms, both formal and informal, rely mainly on internal funds for acquiring machines while the mode of acquisition within the arm's length trade differs across the three technology types and between the informal and formal sectors. The firms acquire the Chinese machines from sales and distribution firms in the domestic market while for advanced country machines the formal sector firms may purchase them directly from foreign markets. For second-hand

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advanced country machines, however, the firms buy some locally, which is the only way by which an informal sector firm can purchase a second-hand machine from advanced countries. Obviously, in the case of Chinese and advanced country machines the transfer involves importation. The importation is done by either domestic sales and distribution firms especially in the case of Chinese machines or the firms themselves, specifically, the formal sector ones and in the case of the advanced country machines.

The analyses on the production coefficients show that the Chinese machines are inefficient compared to the advanced country and Kenyan machines if the machines were operating at rated capacity utilisation. However, at actual daily production rate, the efficiency of the Chinese machines is generally comparable to that for the advanced country machine while the Kenya machines still appears superior to the Chinese machines. Similarly, the indicators on returns show that at actual capacity utilisation the Chinese and Kenyan machines may yield higher returns (and are viable) for the informal sector firms than the advanced country machines while the reverse is true if capacity could reach the rated level. For the formal sector, all investments appear viable whether capacity is underutilised or not although the returns may be much higher if the firms are able to achieve rated capacity utilisation, particularly in the case modified Chinese planer. These results seem to highlight the importance of scale in determining the appropriateness of a technology for a given context or firm.

Finally, the Kenyan machine does not only seem to offer relatively high efficiency and return but it is the most labour intensive, followed by the Chinese machine. However, it is important to note that the apparent superiority of the Kenyan machines over the others may disappear if quality differences in the output of the machines had been captured in the computation of the production coefficients. For the Chinese and advanced country machines such quality differences appear to be very minimal as highlighted in Chapter 6.

In the next chapter, I examine the extent of penetration of the machines from the three sources in the furniture industry and the determinants of the adoption of the technologies by the firms.

Annex to Chapter 7: Indicators of returns on investment

As mentioned in the introductory section, two indicators of return on investment are used in this study. The net present value (NPV) and benefit cost ratios (BCR) are derived for investment in each type of planer for both the formal and informal sectors. The NPV is defined as:

$$NPV(s) = \sum_{t=0}^{n} \alpha_t \, s_t \; = \frac{s_0}{(1+i)^0} + \frac{s_1}{(1+i)^1} + \cdots + \frac{s_n}{(1+i)^n} \qquad (1)$$

Where *n* represents the lifespan of the machines, *α* is the discount factor and *t* is a given year during the life of the machine. *i* is referred to as the discount rate which is assumed to be invariant with time and *s* is the annual revenue the machine generates less the cost incurred in a given year. At *t* equals zero the cost incurred is the acquisition cost of the machines while for the subsequent years the costs incurred represent the operating cost of using the machine to generate income. The formula reflects the basic principle behind NPV analysis, which says that streams of benefit or costs (i.e., negative benefits) occurring in the future are of lesser economic value or provide lesser utility than present streams (Mishan, 1972; Dasgupta and Pearce, 1972). In other words, a dollar in hand today is worth more than a dollar to be realised a year from now, thus, the need to discount the future streams. This is important especially when dealing with investments that last for different time periods. By NPV, an investment is deemed viable if the calculated NPV is positive.

To follow the NPV principle, a discount rate of 10% has been adopted. This is the real lending rate for the Kenyan economy I obtained by simply subtracting inflation from the nominal lending rate of 20%. This nominal lending rate is a 12-month simple average of the commercial banks' weighted average of monthly lending rates for January to December 2012, published on the official website of the Central Bank of Kenya. The inflation rate is also a simple average of monthly (year-on-year) inflation figures for January to December 2012, published on the official website of the Kenya National Bureau of Statistics.

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The rationale behind discounting also underpins the BCR. Being the ratio of the discounted benefits to the discounted costs over the life of the machine, BCR is directly related to NPV in the sense that investments with negative NPV always have BCR of less than one. Unlike NPV, the BCR provides an added advantage of being amenable for ranking the investments of different magnitude in terms of their viability (Dasgupta and Pearce, 1972). By BCR, viable investments are supposed to have BCR greater than one and the greater it is the higher the returns on the investment and the more preferable the investment is to the ones with relatively smaller BCRs.

The subsections that follow describe the components of the revenue and the cost streams associated with operating the machines per year during the life of the machine and how they are derived for the computations in this thesis. The revenues and costs are the main ingredients for calculating the indicators for the returns on investment.

Total cost streams

Two aspects of the total costs of operating the various planers – acquisition and maintenance costs – were discussed in Chapter 6. The acquisition costs were presented Table 6.2 in Chapter 6. With regards to maintenance and repair costs, the respondents were not able to provide reliable information on how much they spend seasonally except for the cost of rewinding broken motors. As noted in Chapter 6, the cost of rewinding Chinese motor is USD 58.82 which accrues about two to three times a year and that for advanced country planer is USD 94.12 which happens once in about every three years. That for a Kenyan planer is not different from advanced country cost because they tend to have second hand motors from advanced countries. Being pessimistic about the Chinese machines, I assume for the case of the Chinese planer that the motor rewinding happens four times a year. This gives a total maintenance cost of USD 235.28 per year for Chinese planer while that for both advanced country and Kenyan machines is USD 94.12 per triennium. Further maintenance costs such as repairing or replacing machine parts such as chains, bearings and cutter blocks may be incurred for all the machines especially the Chinese machine. However they

are not captured in the total cost stream because the respondents could not provide consistent and reliable information about such costs. Hence, the analysis starts with the assumption that such maintenance costs are nil but later relaxes this assumption by adding an annual fixed maintenance cost of USD 100 per annum for the Chinese planer. The reason is that apart from the motor, other parts of the Chinese machines breakdown much more frequently than those of the other machines.

Also, an important element of the operating cost is the rental cost of sheds or premises. However, I leave this cost out of the computation in order to avoid complications associated with apportioning rental cost to a machine. Such detailed apportionment does not happen in practice. In terms of the calculated indicators presented in this chapter, this omission may favour the formal sector because of the large difference between rental costs of the rickety sheds of the informal sector operators and the well-built premises of the formal sector firms, as discussed in Chapter 5. In addition to the other operating costs mentioned so far, running the planers also involves labour and electricity cost. The details on how these costs are measured for the purpose of computing the indicators are discussed as follows.

Labour cost

The labour hours used in machine operator firms in the informal sector are compensated for on commission basis. Information obtained from the machine operator firms in the informal sector indicates that they (two people – the main operator and an assistant) receive 30% to 50% of the daily proceeds in wages. For the needed computation, I assume 40% for the daily compensation rate for labour, which is an average of the indicated bounds. The reward system in the formal sector is however different. Usually, the operators receive a monthly salary. However, of the 8 firms interviewed in the second round, only one operator for an advanced country planer gave out his monthly salary of 18,000 Kenya Shillings. Apparently, this employee had worked for that firm for over 25 years; hence, his salary appears to be a poor representation of the average for the sector. I therefore rely on the official minimum

monthly wage for Kenya in 2012 which was 9,724.30 Kenya Shillings[33]. With five working days in a week and eight working hours per day, this figure comes to 60.78 Kenya Shillings hourly rate for a worker. On the basis that two people are required to operate the planer, the total hourly wage cost for operating the planer is 121.55 Kenya Shillings, which converts to about 1.43 US dollars.

Cost of electricity

The cost of electricity for the firms is generally recorded as a lump sum as in the case of rental cost of sheds or premises and the firms have no system of apportioning the cost to individual machines. However, knowledge of the capacity of the machines' motor (horse power or kilowatt per hour – kwh), the daily run of the machines and the tariff rates of the power supplier makes it possible to estimate the cost of electricity consumed for a particular level of production with the planers. Chapter 6 showed that a typical Chinese planer has a three horse power (2.206 kwh) motor while that for advanced countries has 6 horse power (4.413 kwh). The corresponding figures for Kenyan and modified Chinese planers are five (3.677 kwh) and 4.4 (3.309 kwh) respectively.

Two different tariff rates from the power supplier are used in this study. Kenya Power provides varying tariff rates for different categories of consumers. I make use of the first two of the commercial tariff rates, which correspond with 240V and 415V supply, as defined in the company's tariff guide, published online by Ray of Solaris. The rates for the former and latter are respectively used for the computations for the informal and formal sectors. The rate recorded for November 2012, the time around which the data were collected, are 19.78 Kenya Shillings per kilowatt hour for 240V and 16.34 Kenya Shillings per kilowatt hour for 415V.

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[33] This is the minimum monthly wage rate for machine attendants/operators reported by Legal Notice 71 of 2012, under Kenya's labour Institution Act 2007 (No. 12 of 2007), published online by the Kenya Laws (2012)

Revenue stream

This section provides the monetary measure of the level of production that the various planers can achieve in each year of the life of the machine. This measure is obtained by multiplying the output of the machines in terms of the number of feet they can plane, as determined in Section 7.1.1, by the unit charge (price) for a foot. The monetary value of production could then be added to the scrap value to obtain the total revenue realisable from the machine. However, I assume zero scrap values for all the planers. The reason can be found in the relatively long actual and expected life of the machines especially the ones from advanced countries. As noted in Chapter 6, the firms do not give up on the machines easily, thus, they seem to exact benefits beyond what the normal economic life of the machines should offer.

Money value of physical output

Obtaining the money value of output is quite simple for the informal sector. The machining operator firms charge Three Kenya Shillings per foot. Using 300 working days[34] per year, the total revenue per annum is easily obtained by multiplying the daily production level by the unit charge and the number of working days in a year. It should be noted that the fact that the unit charge does not capture the qualitative differences in the work done with the different planers pose some limitation on the calculated indicators particularly with regards to the social value placed on the various investments.

Unlike the informal sector, there is **no directly observed unit charge** or **market price** for machining services in the formal sector because such activities are fully integrated in the individual firms. I therefore assume the unit charge for the formal sector to be one and half (1.5) times that of the informal sector based on the fact that products/services from the formal sector are normally much more expensive than those from the informal sector. As noted in section 5.2.3 of Chapter 5, products from the formal sector could sell for over four times the prices of those in the informal sector including the Ngong' cluster. However,

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[34] I use 300 working days instead of 312 (6 days a week times 52 weeks) because of various festive periods such as Christmas and national holidays.

machining work (i.e. preparation stage of the furniture manufacturing process[35]) is less skill-demanding, compared to the other stages such as designing, joinery and upholstery, which together constitutes a major determinant of quality difference between products from the two sectors. In other words, value added at the preparation stage appears to be much less than the other stages. Thus, much of the price difference in the final products from the formal and informal sectors seem to emanate from the designing, joinery upholstery work as well as differences in the quality and cost of other inputs such as raw materials and rental cost of premises. This rationalises the notion that although the unit charge for planing in the formal sector should be higher than that for the informal sector but not proportionately related to the price of the final products (furniture).

Interpretation of calculated indicators of returns

The indicators of the returns on investments are presented separately for the two sectors. This separation is necessary because the firms in these two sectors face different output and input prices. Like the discussion on production coefficients, for each sector, the indicators are provided for the two scenarios presented in Table 7.1, that is, production at *rated capacity* and production at *actual (daily demand-driven) capacity* utilisation. The subsection further presents indicators on the Chinese planer for both formal and informal sectors when additional maintenance and repair cost of USD 100.00 are incurred every year. However, indicators for the Kenyan planer are not reported for the formal sector because none of the formal sector firms interviewed had invested in the Kenyan planer.

Working at rated capacity

At the rated capacity, all the machines are profitable in both the informal and formal sectors. As Table 7.5 and 7.6 indicate, all the machines yield positive NPVs. However, the tables also show that for both sectors the advanced country and Kenyan machines produce higher BCR than Chinese machines, whether modified or original. For the informal sector, the advanced country planer when operating at twice the hourly rate of the original Chinese planer

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[35] The various stages in the process were discussed in Chapter 4 in section 4.5.2

produces a BCR of 1.27, which is close to that for the Kenyan machine (1.26) but higher than 1.22 and 1.21 for the original and modified Chinese planers respectively. The corresponding figures for the advanced country planers and Chinese planers in the formal sector are respectively 2.02 and 1.27 (1.54 for the modified machine). The modified Chinese planer appears to yield better returns than the unmodified particularly in the formal sector. The tables show that the modified yields higher NPV for both formal and informal sectors.

The NPV and BCR also show that investments in the formal sector yield higher returns than that in the informal sector. It is also important to note that within the informal sector, the Kenyan planer seems to offer better returns than the Chinese planer. This however depends on the operator's ability to charge the same price on a relatively inferior output, as the operators of the Chinese planer, with no negative impact on demand.

Table 7.5: Working at rated capacity – Informal sector

Type of planer	Assumptions	Capacity (daily run in hours)	NPV	BCR
China	Original (unmodified)	6	3,471.09	1.22
	Modified China working at 1.33 times original China's hourly rate	6	4,070.06	1.21
Advanced country	Working at 1.5 times original China's hourly rate	12	7,020.82	1.09
	Working at 2 times original China's hourly rate	12	2,3730.49	1.27
Kenya	Working at 1.33 times original China's hourly rate	8	8,064.58	1.26

Table 7.6: Working at rated capacity – Formal sector

Type of planer	Assumptions	Capacity (daily run in hours)	NPV	BC ratio
China	Original (unmodified)	6	5644.22	1.27
	Modified China working at 1.33 times original China's hourly rate	6	12427.19	1.54
Advanced Countries	Working at 1.5 times original China's hourly rate	12	41896.06	1.50
	Working at 2 times original China's hourly rate	12	84243.76	2.02

Working at actual (daily demand-driven) run

Working at the demand-driven capacity utilisation has a major negative effect on the returns, suggesting that under capacity utilisation is a challenge to investment in this sector. Under capacity utilisation is not a characteristic of only the furniture making industry but a feature of Kenya's manufacturing sector as whole. A report by Kenya Association of Manufacturers (2006) indicated that close to 90% of manufacturing firms in Kenya are underutilising installed capacities.

Table 7.7: Working at actual daily demand-driven run (three hours) – Informal sector

Type of planers	Assumptions	Capacity (daily run in hours)	NPV	BCR
China	Original (unmodified)	3	413.24	1.05
	Modified China working at 1.33 times original China's hourly rate	3	1,292.05	1.12
Advanced country	Working at 1.5 times original China's hourly rate	3	-6,266.38	0.77
	Working at 2 times original China's hourly rate	3	-2,088.97	0.93
Kenya	Working at 1.33 times original China's hourly rate	3	2,333.31	1.19

Table 7.8: Working at actual daily demand-driven run (three hours) – Formal sector

Type of planer	Assumptions	Capacity (daily run in hours)	NPV	BC ratio
China	Original (unmodified)	3	1657.58	1.14
	Modified China working at 1.33 times original China's hourly rate	3	5470.62	1.45
Advanced Countries	Working at 1.5 times original China's hourly rate	3	3910.80	1.14
	Working at 2 times original China's hourly rate	3	12854.06	1.44

At the actual daily run, the NPVs show that investments in the Chinese planer (modified) and Kenyan planer in informal sector are still viable while the advanced country machine becomes unprofitable (Table 7.7). Correspondingly, the table shows that the BCR for the advanced country planer, even when it is operating at twice the rate of the original Chinese planer, is less than one. The BCRs show that the Kenyan machine is again preferred to the modified Chinese planer while the modified Chinese planer is in turn preferred to original

Chinese planer. It therefore appears that when capacity is underutilised, investment in planers in informal sector is viable only for the modified Chinese and Kenyan planers. For the formal sector, the Chinese planer (both original and modified) and advanced country planer are profitable although the modified Chinese planer produces a slightly higher BCR than the advanced country planer (Table 7.8). Obviously, the reason for the relatively low profitability of advanced country machines at this rate of production in both sectors is that the advanced country machines are more capital intensive and thus suffer disproportionately from capacity underutilisation given that all other costs are variable.

Additional maintenance cost for Chinese planers

Table 7.9 reports the indicators when additional maintenance cost of USD 100.00 per annum is assumed for the Chinese planer (both original and modified). The indicators are calculated for actual daily (demand-driven) capacity for both formal and informal sector. The corresponding indicators for rated capacity production levels are not reported because the advanced country machines already yield better return than the Chinese when there is no extra maintenance cost for the Chinese machines. The table shows that the NPVs and BCRs are better in the formal sector than in the informal sector. In fact, the original Chinese planer produces a negative NPV with a BCR less than one in the informal sector while the BCR for investment in the modified planer in the informal sector is only slightly greater than one. Interestingly, the BCRs for both the original and modified Chinese planers reported in Table 7.9 for the informal sectors are better than the corresponding figures for the advanced country machine reported in Tables 7.7. Thus, even when the Chinese machine is not modified, it appears as a relatively more viable investment option for the informal sector firms when production at the actual daily demand-driven rate.

Table 7.9: Actual daily run with additional maintenance cost for Chinese planer

Assumptions	Capacity (daily run in hours)	NPV	BC ratio
Informal			
Original (unmodified)	3	-145.36	0.98
Modified China working at 1.33 times original China's hourly rate	3	733.45	1.07
Formal			
Original (unmodified)	3	1098.98	1.09
Modified China working at 1.33 times original China's hourly rate	3	4912.02	1.38

Generalising findings from planers

It should be noted that the above analysis using planers assumes that planers are acquired as standalone purchases or machines, which is true in the case of the informal sector firms that only specialise in machining services (planing). For the other firms particularly the formal sector firms, however, planers are embedded in a production system consisting of other complementary machines. If I was able generate the needed data to compute the indicators for all the machines together, the findings on the profitability of the different technologies might change for these firms. However there was no hint in my fieldwork that the changes will be significant and I believe that the relative performance of the planers from the three sources is not dissimilar to the other set of machines, as alluded to in section 7.1.1 of this chapter.

CHAPTER 8 : PENETRATION AND DETERMINANTS OF ADOPTION

8.0 Introduction

The aim of this chapter is to present findings on the level of penetration of the technologies from China, advanced countries and Kenya (jua kali) in the furniture industry. The chapter begins with a discussion on the level of investment in the machines by the firms before delving into the patterns of penetration of the three types of technologies across the formal and informal sector as well as between the different informal sector clusters. It also highlights several possible explanations for the observed patterns of penetration based on evidence presented in Chapters 5 to 7 and further information presented in this chapter with regards to factors such as the characteristics of the machines, target market of the firms and infrastructural conditions of their premises or sheds. Moreover, firm and operator characteristics are examined as factors influencing choice (or adoption), thus penetration, in a sequential logit model. Using bivariate/multivariate probit models, complementarities between the adoption of Chinese technology and the others are also examined.

8.1 Level of penetration

8.1.1 Investment in machines and market-based cooperation

As alluded to in Chapter 4 under section 4.5.2, not all the firms interviewed in the first round of the survey (i.e. the 131 firms of which 20 were formal sector firms) have invested in the automated "light-duty" machines studied in this research: Some of them specifically those in the informal sector have invested only in hand tools and/ or power tools. Figure 8.1 indicates that 61% of the 131 firms interviewed have invested in the automated light-duty machines, which have been simply referred to as "machines". For the informal sector firms, 54% have invested in these machines compared to 100% for the formal sector firms. Moreover, between the informal sector firms and the formal sector firms that have invested in the machines, there is a large difference in the number of the machines mounted in their

workshops. Walking through the workshops of these firms, I found that a typical informal sector firm that has invested in these machines normally has one or two while its counterpart in the formal sector has assorted machines that perform many differentiated functions. This observation aligns with findings by Bigsten *et al.* (2000). In a study of 109 firms in Kenya's manufacturing sector they found that the formal sector firms are seven to eight times more capital-intensive than their informal sector counterparts. This may be associated with the fact that the informal sector firms have relatively limited access to finance compared to the formal sector firms, as was noted in Chapters 5 and 7.

Figure 8.1: Proportion of firms (%) having a machine by sectors (N=131)
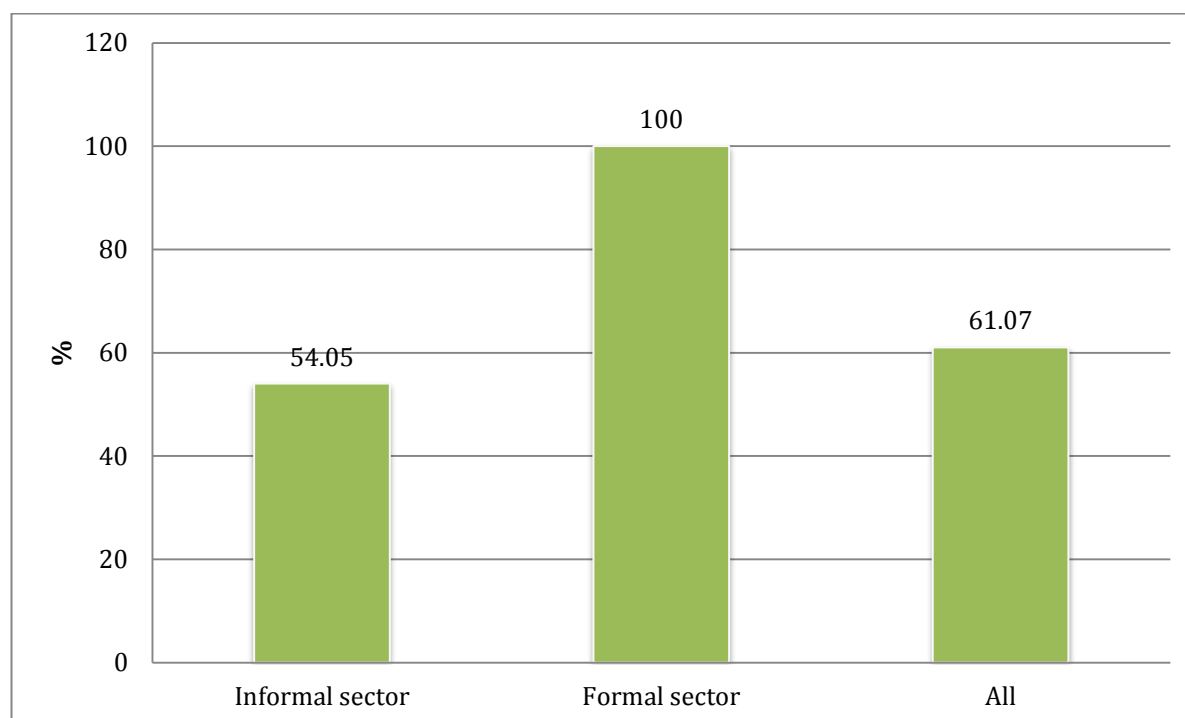
Source: Field data, 2012/2013

The informal sector firms that have invested in machines tend to invest in complementary machines so that, for example, if firm A has invested in a Chinese planer, firm B (A's neighbour) would factor this into his investment decision and buy a different machine, say a band saw from Kenya. More evidence on this can be found in the following statement from an informal sector operator in the Kibuye cluster:

> … we here we cannot afford all the machines, so we share the machines we have
> with other people. You cannot purchase all the machines, they are very expensive

and as per our production rate…even the one machine [planer from China] I have I cannot dwell on it all by myself. People bring their timber so I can plane for them to get money to do servicing [maintenance] and pay my rent … (Field interviews, 2013)

The opportunity to specialise and forge such complementarity therefore allows the firms to specialise and provide reciprocal machining services, albeit, through the market mechanism (arm's length) rather than non-market cooperative structures. This kind of cooperation exists mainly in the informal sector, whereas the formal sector firms rely extensively on their internal capacity or capabilities. The opportunity for this complementarity also explains why the firms invest in fewer machines compared to the formal sector ones. This finding generally supports the literature on cooperation and collective efficiency of industrial clusters (Rabelloti, 1999; Schmitz, 1999; and Nadvi, 1999). However, this form of cooperation can be described as passive especially in relation to the active character of cooperation emphasised in the above studies where joint actions by the firms lead to joint projects or investment (e.g. joint investment in equipment), information sharing and labour training.

The use of market mediated forms of cooperation within the informal sector, specifically between firms that manufacture furniture and also provide machining services, to a limited extent, may be associated with the relatively low degree of trust between the operators especially those in Gikomba cluster, which was highlighted in Chapter 5. As Uzzi (1997) has indicated, arm's length relationship in exchange tends to rely much less on trust compared to other forms of exchanges.

An explanation for the large difference between the formal and informal sector in terms of investment in machines can also be found in the quotation from the informal sector operator in the last but two paragraphs. That is, while some of the informal sector firms do not have financial resource to embark on this investment, others find it economically unviable because their production level is too low to exhaust the capacity such investment will create. They also believe that the supply of machining services within their clusters has reached saturated levels. Thus, rather than acquiring any machine they rely on other furniture making firms which have undertaken such investment or firms which specialise only in machining services

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in their clusters. The decision to invest in machines is therefore made within a framework of strategic interactions between the firms operating within the same informal sector cluster.

8.1.2 Level of penetration of the three technology types

Figure 8.2 presents the penetration rate by the technology types (machines from China, advanced countries and Kenya) across the two sectors and the informal sector clusters. These rates have not been calculated for the entire sample but for the 61% of the firms, who have invested in machines. The rates also do not indicate the extent to which a firm has invested in any of the technologies but are based on whether a firm has invested in at least a machine belonging to any of the three categories of technologies. (Further details on the firms' degree of investment in a machine from a given source are provided in Figure 8.4 under subsection 8.1.3). It should also be noted that for any of the firms, investment in any one type of the technologies does not exclude investment in the other types if the firm has the resources to do so or finds such investment economically viable.

Of the firms that have invested in machines, Figure 8.2 shows that 61% have invested in at least one Kenyan machine, compared to 45% for Chinese machines and 37% for advanced country machines. However, the formal sector firms mainly rely on advanced country machines. While all of formal sector firms have machines from advanced countries, 25% and 20% of these firms have invested in Chinese and Kenyan machines respectively. The informal sector firms however tend to rely more extensively on Kenyan machines (75%), followed by Chinese machines (52%) and less on advanced country machines (15%).

Within the informal sector, the Ngong' cluster has the highest penetration rate for Chinese machines (75%), followed by Kibuye (68%) and then Gikomba with a low rate of 12%. For Kenyan machines, however, Gikomba has the highest level of penetration (88%), closely followed by Ngong' with 71% and then Kibuye with 63%.

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Figure 8.2: Penetration (%) of the technology types (sources) by clusters/sectors
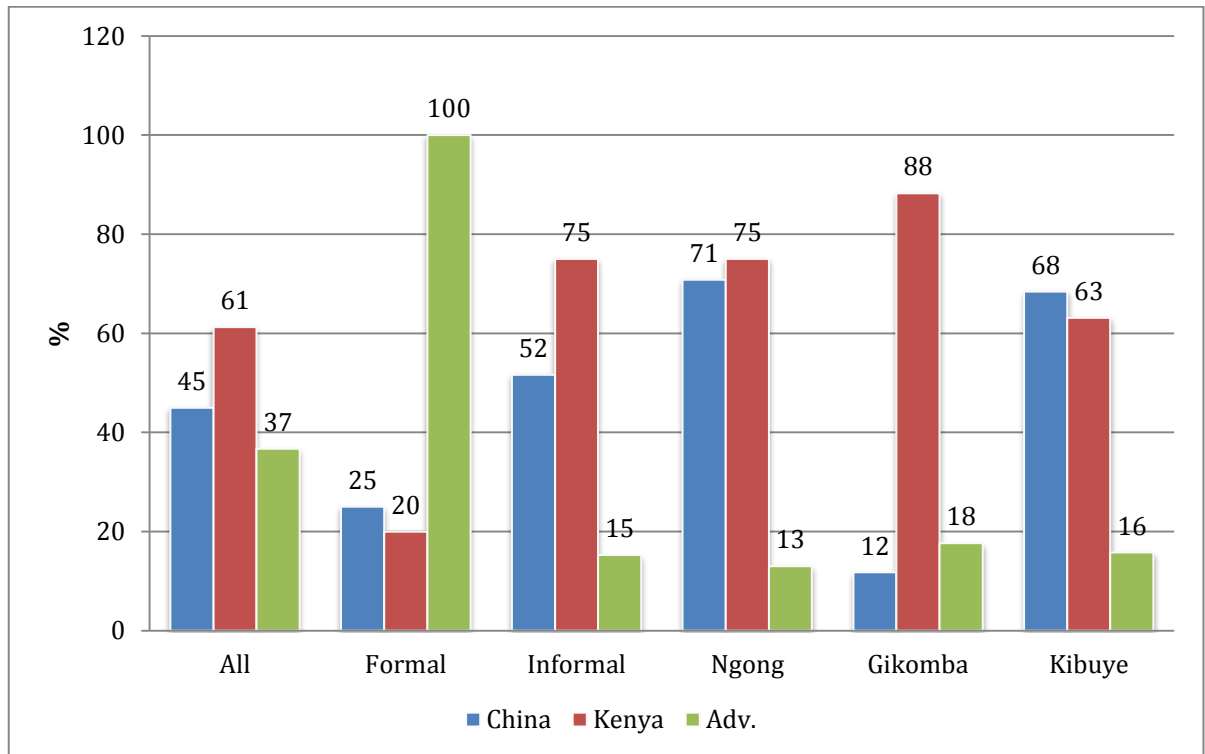
Source: Field data, 2012/2013

A number of factors may account for the differences observed in the levels of penetration for the two sectors and across the informal sector clusters. The firm and operator characteristics may influence the adoption patterns, as discussed below in Section 8.2 of this chapter. However, equally important are factors such as the target markets of the firms, the technical and economic characteristics of the machines that were highlighted in Chapter 6, the cluster level factors such as the nature of infrastructural facilities (specifically, nature of premises or sheds and electricity supply, discussed in Chapter 5), and the profitability and mode of acquisition of the machines discussed in Chapter 7. In the paragraphs that follow in this subsection I discuss how these factors affect the adoption of the different technologies.

Target market as a source of explanation

Chapter 5 showed that the formal sector firms produce high quality furniture and mainly target rich households, the corporate and public sector offices. The informal sector firms on the other hand largely produce to meet the demand from low income categories of the population. However, it was also noted in Chapter 5 that the firms in the Ngong' cluster

appear to pose a competitive threat to the formal sector firms with respect to market opportunities in the middle income segment of the market. Producing high quality furniture to satisfy sophisticated consumers who may also place relatively more emphasis on prompt delivery and warrantee requires investment in machines with the needed level of functionality and reliability. Contrarily, satisfying less demanding consumers allows firms to make do with lower quality machines, particularly with regards to precision and flexible of the functions and the run of the machines. Thus, for the formal sector firms the advanced country machines show up as the best choice while the nature of demand facing the informal sector firms generally allows them to accommodate the disadvantages associated with the Kenyan and Chinese machines.

Between the informal sector clusters, the Ngong' cluster firms produce the highest quality of products, which find patronage among some middle income consumers. Thus, customers of the Ngong' cluster are more demanding in terms of product quality, designs and finishing than their counterparts in the other informal sector clusters. The Chinese machines offer better precision and flexibility of functions than those from Kenya, as explained in Chapter 6. Consequently, the need for the firms in Ngong' cluster to meet the demand of relatively sophisticated customers may explain why relatively more of the firms in Ngong' cluster have invested in Chinese machines compared to the others, particularly those in the Gikomba cluster.

Characteristics of machines as a source of explanation

Many technical and economic characteristics of the machines may influence the level of adoption. However, as established in the Chapter 6, the most important of these factors for a choice between the three sources of machines are durability, functionality (precision and flexibility of functions) and the acquisition costs of the machines. Firms in the informal sector generally cannot afford advanced country machines in spite of their desirable qualities with regards to durability and functionality, making these firms to settle for Kenyan and/or Chinese machines. They (especially those operating in Gikomba cluster) prefer the Kenyan machines

to Chinese machines mainly due to the relatively high durability of Kenyan machines. They however choose Chinese machine specifically the planer over Kenyan ones in situations where they have higher requirement for precision and flexibility of functions. To a limited extent, this explanation for the informal sector firms' investment into Kenyan and Chinese machines is also true for a few of the formal sector firms that have invested in Kenyan machines. However, affordability of advanced country machines (particularly second hand machines) for these formal sector firms to a great extent is less problematic.

Figure 8.3: Respondents' ordinal evaluation of factors influencing choice
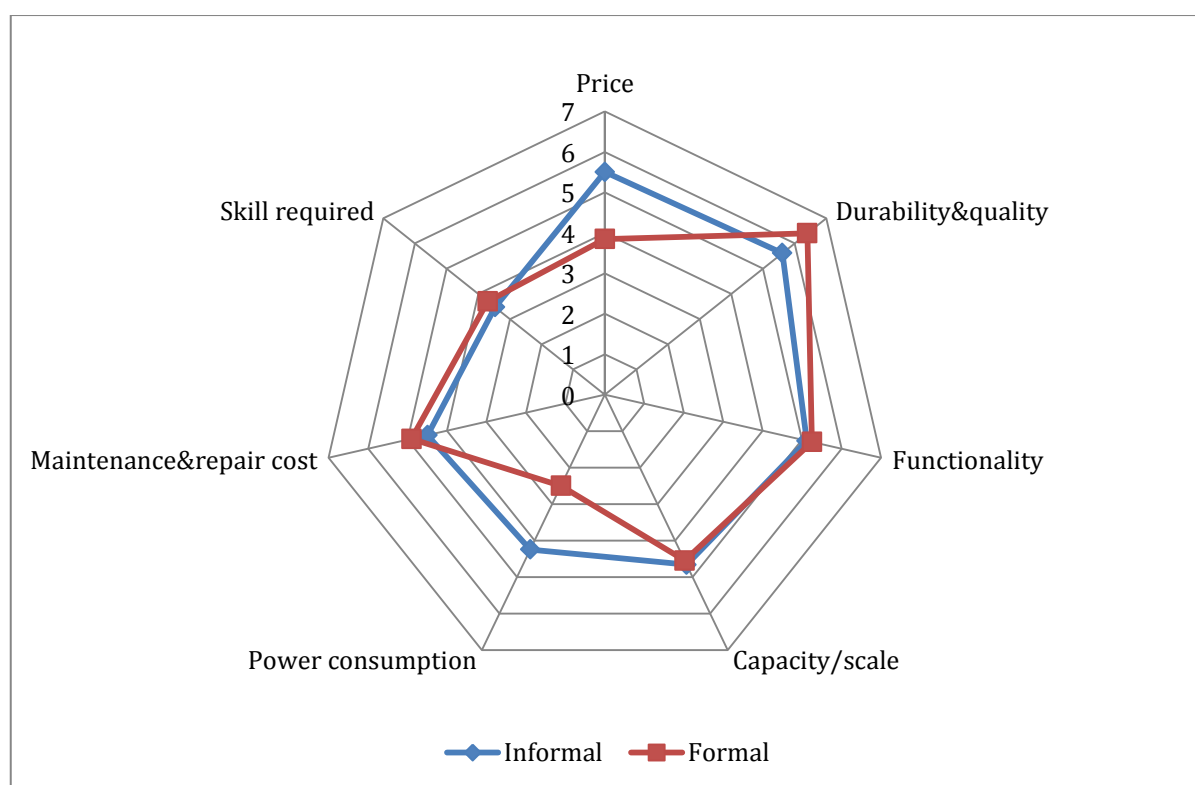
Source: Field data, 2012/2013

Generally, the above explanation for the patterns observed in Figure 8.2 accords with the respondents' self-reported evaluation of different factors that influence their choice between the different sources of machines or technologies which have been presented in Figure 8.3. On a scale of one to seven (where one means no influence and seven means very high influence), they were asked to indicate the extent to which each of the factors presented in the figure affects their choice between the different technology types. The figure shows that for informal sector firms, price (a proxy for purchasing cost) is the most important factor,

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followed by durability and then functionality (precision and flexibility) of the machines. For the formal sector firms, however, durability comes first, followed by functionality and then maintenance and repair costs, and in fact price is less important than the capacity/scale of the machine. Thus, the characteristics of the machines and the firms' self-ranking on the factors which influence their choice help explain the pattern of penetration or adoption across the formal and informal sector firms.

Profitability and mode of acquisition of machines as sources of explanation

Chapter 7 showed that Chinese machines and particularly Kenya machines appears to yield higher returns than the advanced country machines particularly for the informal sector when the machines operate at actual demand-driven daily capacity utilisation. In fact, the calculations presented in the annex to Chapter 7 show that at the actual capacity utilisation, the advanced country machines may yield negative net present values for the informal sector firms. While I did not collect information on whether the firms did computations similar to those in Chapter 7 before investing in the machines, it is not difficult to believe that the firms' perspective about the amount of returns realisable from the machines will have a major influence on their decision to choose a technology over other alternatives.

Also noted in Chapter 7 was the fact that purchasing advanced country machines may imply that the firm has to buy directly from foreign markets and manage the complexities surrounding the importation process. This makes the advanced country machines generally unattractive to the informal sector firms. The reason is that not only may such process be financially cumbersome for the firms but also given their limited educational background (as discussed in Chapter 5) they may lack the technical knowhow and the courage to engage in such processes. However, it should be noted that if there had been a large demand for these machines, then surely traders would have emerged in Kenya.

Clustering and nature of infrastructure as sources of explanation

Cluster level characteristics such as infrastructural conditions may matter for the choice between the three types of technologies. As shown in Chapter 5, infrastructural conditions in

the informal sector clusters especially the Gikomba cluster are weak. Being highly prone to fire outbreaks, flooding, theft and pilferage and with irregular/illegal power connections, these informal sector firms are naturally deterred from investing in high quality and expensive machines from advanced countries even when they can afford them and the nature of demand for their products warrants such investment. They are also less inclined to invest in less robust machines from China which, apart from being slightly more expensive than Kenyan machines, may not be able to withstand the harsh conditions in which they operate. For formal sector firms, although infrastructural conditions may not be totally perfect, what is available to them as discussed in Chapter 5 seems to meet the minimum required for investing in machines from advanced countries.

As shown in Figure 8.2, penetration of Kenyan machines in the Gikomba cluster is the highest among the informal sector clusters. This may not be associated only with the fact that the Gikomba cluster has the weakest infrastructural conditions. Another important factor is that the Gikomba cluster is a neighbour to another cluster of informal sector firms manufacturing the Kenyan machines in Nairobi. Thus, there appears to be a relatively strong forward linkage between the fabricators of the Kenyan machines and the furniture making firms in the Gikomba cluster compared to the linkage between the firms in the other clusters and the machine fabricators.

8.1.3 Penetration of the four types of machines by sources (technology types)

Figure 8.4 presents the numbers of the four different types of machines from China, advanced countries and Kenya that were studied during the second round of the interviews with the firms. These numbers were presented in Chapter 6, but they have been reproduced in this chapter because they indicate the relative extent of adoption of each type of machines within a particular technology type. Although the firms were purposively selected, the selection and particularly the number selected for each category was also largely influenced by the availability of the machines in the workshops of the firms. For example, among the Chinese machines, the planer is the commonest in the furniture industry in Kenya and all

those I saw were of similar design: The only difference a casual observer will notice has to do with the differences in brand names, of which the most popular are LIDA and AICO. The other types of machines from China (lathe, band saw and particularly saw bench) were rare to find as the numbers in Figure 8.4 show. In fact, the figure does not present any saw bench from China because I did not find one in any of the workshops I visited (including those of the informal sector firms) throughout the seven months of fieldwork.

Figure 8.4: Penetration (n) by each type of machines for the three sources
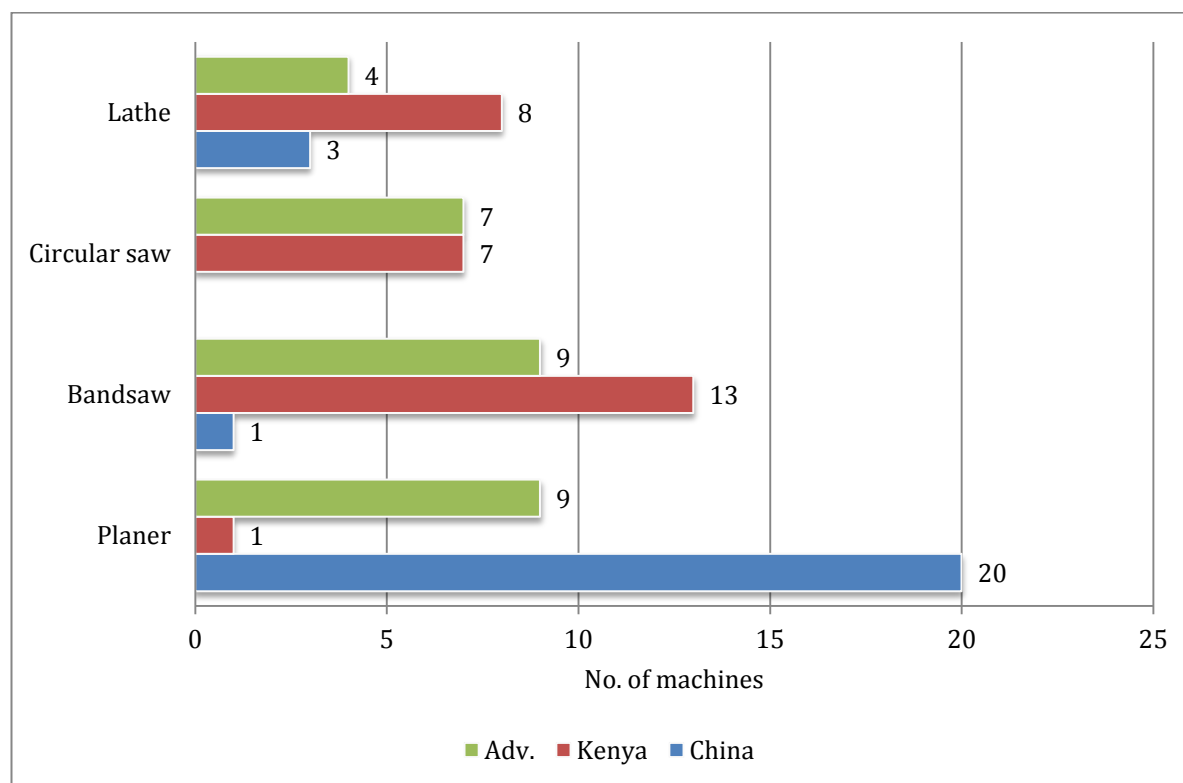
Source: Field data, 2012/2013

Kenyan planers were relatively hard to find. I chanced on only two during my fieldwork, of which one is pictured in Figure 6.1 and was found in the workshop of an informal sector operator while the other was found going through refurbishment in the workshop of a repairer. The respondents, especially those in Kibuye cluster, indicated that the Kenyan planers were once common in their workshops. However, with the advent of the cheap Chinese planer, the operators started moving away from the Kenyan planers to those from China mainly because Chinese planers offer higher precision and flexibility than the Kenyan planers. One of the respondents reported:

> … it [Chinese planer] is cheap, machines from England are too expensive and the jua kali planing machine does not work very better. Because the table for surface planing it is zigzag [not smooth] so when you are planing it does not give smooth surface, a perfect finish and they have not assembled it in good order and it makes a lot of noise because it is not heavy. (Field interview, 2013)

An anecdote from another person in the same cluster is very informative:

> … there was a time that the planing machine, the band saw and the lathe machine we had here were all jua kali made machines. Then something changed; we started seeing these advanced ones from China and people started changing. You know our customers, when you work with the advanced machines, the finish is very better than the jua kali ones. So customers started rejecting the jua kali so people started rushing for the advanced planing machine from China. But [for] the lathe and this band saw, the ones from jua kali are still ok and that is why they are still around… (Field interview, 2013)

Thus, the other machines from Kenya such as the band saw and lathe are quite popular, as shown in Figure 8.4. In addition, a few of the formal sector firms have invested in one or two of these Kenyan machines (Figure 8.2).

8.2 Firm and operator characteristics' influence on choice/adoption

The section presents the statistical and econometric analysis of the influence of the firm and operator characteristics on the firm's adoption decisions concerning the technologies. The subsection also quantitatively tests for the complementarity between the adoption of Chinese machine and Kenyan machines, which was highlighted in Section 6.3.2 of Chapter 6 and alluded to in Section 8.1 of this chapter, as well as that between the advanced country technology and the others.

8.2.1 The regression models

Investing in technologies (machines) from any of the three sources generally involves a two-stage decision making process where the firm is confronted with a set of choices at each stage. In the first stage, the firms decide on whether to invest in machines. Those that choose to invest in machines then decide on whether to buy machines from a particular source or type of technology. Thus, investing in Chinese technology for example generally involves two stages of decision making as described in Figure 8.5.

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Figure 8.5: Nature of dependent variables
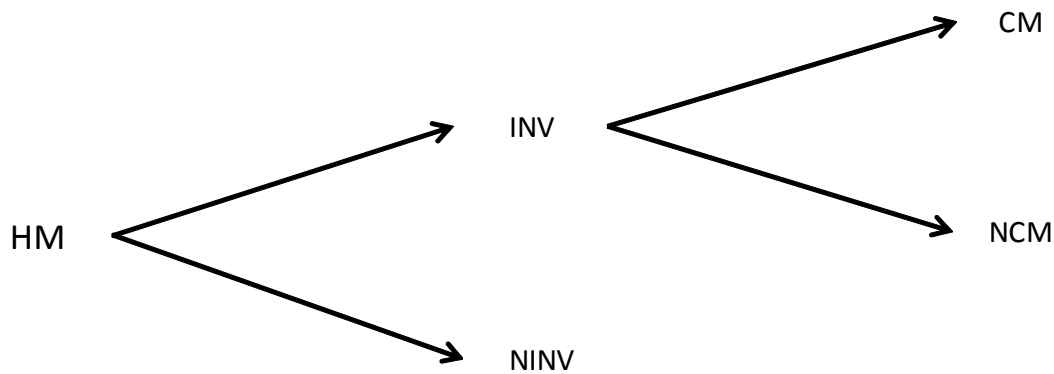
The two stages correspond to two questions the firms were asked during the first round of the survey, which is used in the regression analysis in this section. They were initially asked to indicate whether they have invested in machines. The outcomes can be diagrammatically represented (as Figure 8.5 shows) as INV and NINV which respectively represent the situations where the firm has undertaken such investment and where the firms has not embarked on such investment. Those who have invested in machines were then asked whether they have invested in Chinese technology or not with the outcomes represented in the figure as CM if the firm has undertaken such investment and NCM if it has not invested in Chinese machines. These two decision making process also generally characterise investment in other technologies. The analysis takes account of each technology type (i.e. the source) but not the machine types. In other words, no distinction (for example) is made between investment in Chinese planer and investment in Chinese band saw.

Based on the above description of the sequence of decision making, the firm's adoption of technologies from any of the three sources can be examined in a sequential logit model. Also referred to as sequential response model, continuation ratio logit, model for nested dichotomies or Mare model (Buis, 2011), sequential logit involves estimating a separate logistic regression for each stage of the decision making. The stages are sometimes referred to as transitions since only a proportion of the sample at the previous stage moves to the

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ensuing stage. In this study, only those who have chosen to invest in machines move to the next stage of deciding whether to invest in a technology from a particular source, say China. As shown in Figure 8.5, each of the stages involves dichotomous or binary outcomes, of which "success" (i.e. adoption) and "failure" (i.e. non adoption) are respectively ascribed a value of one and a value of zero, and serve as the dependent variables in the various regressions. Hence, for this study they produce the following logit regression models where the outcome depends on a set of independent variables:

$$p_1 = \frac{\exp(X\beta_1 + \varepsilon_1)}{1 + \exp(X\beta_1 + \varepsilon_1)} \qquad (1)$$

$$p_2 = \frac{\exp(X\beta_2 + \varepsilon_2)}{1 + \exp(X\beta_2 + \varepsilon_2)} \qquad (2)$$

$$p_3 = \frac{\exp(X\beta_3 + \varepsilon_3)}{1 + \exp(X\beta_3 + \varepsilon_3)} \qquad (3)$$

Equation 1 corresponds to the first stage for which a firm chooses to invest in machines while equation 2 also corresponds to the first stage but for the situation where the firm chooses not to invest in machines. Equation 3 represents the second stage where a firm that has chosen to invest in machines decides to invest in machines from a given source, say China. The number subscripts represent the different equations. β and *X* respectively represent the matrices for the coefficients and independent variables. *P* is the matrix of *probability of success* such that an element of P_1 in equation 1 is the probability that a firm chooses to invest in machines, an element of P_2 is the probability that a firm chooses not to invest in machines and an element of P_3 is probability that a firm which has invested in machines chooses to invest in machines from a particular source, say China machine. *ε* in each of the equations is a matrix of *error terms* for each of the equations.

The sequential logit regression assumes that the characteristics of alternatives at the second stage of the choice process do not affect the outcome at the first stage (Ophem and Schram, 1997; Nagakura and Kobayashi; 2009). According to Ophem and Schram (ibid), this assumption is realistic if the effort (by the firms) to find out about the differences in the

alternatives at the second stage is costly or when choice at the first stage "touches other issues than the choice [at the second stage]" (1997 p 134).

Equations 1 to 3 model the adoption of a technology as a function of the characteristics of the firms and their operators only, which means that the matrix X contains only variables measuring the characteristics of the firms and their operators. Thus, the characteristics of the technologies or alternatives (including the transfers mode) in the choice set do not enter the regression equations. This is because some of the characteristics such as acquisition and maintenance costs are only observed after the firm has chosen to invest in a machine from a particular source. Moreover, the characteristics of the machines or factors specific to a technology type do not seem to vary across respondents. As alluded to in Chapter 6, quality (flexibility and precision) and durability of machines from a particular source found in the furniture industry generally do not vary across firms. Similarly, purchasing cost cannot vary if the market functions well, and in fact I observed only slight variations of the prices of a machine from a particular source across the sales and distribution firms. Consequently, it is assumed in this study that the effects of the characteristics of the technologies on an individual's choice do not deviate substantially from the average for the sample or population. Hence, rather than being used as independent determinants of the alternatives as in the case of nested logit models (Greene, 2003), the characteristics of the alternatives are regarded as purely intrinsic determinants of the alternatives in the models.

However, the weakness of the model is that the effect of unobserved heterogeneity resulting from variables that may influence the choice but are not included in the model cannot be accounted for (Cameron and Heckman, 1998). In this regard, it should be mentioned that many variables, which may influence the choice do not enter the regression analysis because of two reasons. First, data were not collected on some of the variables because they were difficult to measure (e.g. firm level profit and financial performance in the informal sector). Second and more importantly, the sample size (131) for the regression and particularly for the second stage (80) is not large enough to accommodate a large number of regressors (independent variables), even if all the data were available. The minimum sample

size for logit regression should satisfy the condition that the sample size divided by the number of parameters (*β*) to be estimated should not be less than 10 (Hosmer and Lemeshow, 2000). This means that the second stage regression cannot take more than eight regressors. The consequence is that some of the variables for which data is available (including possible interactions between some of them) will also not enter the regression equations.

The impact of the above problem is that it becomes difficult to derive causal relationships between the dependent variables and the regressors used in the analysis. The relationships derived from the analysis should be observed as correlations and any causality implied in the interpretations of the regression results is assumed. However, the advantage of the regression analysis over simple correlation analysis is that it helps control for some of the extraneous variables that may confound the correlation between the variables.

The independent variables used for the various regression models are measured as described in turns as follows:

a. Log[36] of firm age: Firm age is a continuous variable, which means it takes metric values instead of discrete values. All the regression models use the logs of the firms' ages. This variable is represented in the tables of the results as *Agelog*.

b. Log of firm age squared: Shown in the results as *Agelog2,* this variable is included to capture the likely nonlinear impact that experience which comes through age may have on adoption of technology.

c. Firm size: The size of firm is measured using the total number of employees the firm has, which was also collected as a continuous variable. The log of the variable enters the regression models and it is represented as *firmsize*.

d. Firm's access to finance: Firm's access to credit, which is represented in the tables of the results as *Acc_Fin* enters the regression equations as an index of six variables. That is, six questions measuring access to finance were combined to form a single

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[36] This transformation does not change the extent of variation in the variable and its association with the dependent variables. It is used here just to improve the appearance of graphs from the regression analysis, for example, those in Figure 8.6 particularly with regards to the scale of the x-axis.

index measuring access to finance. The index is the First Principal Component, which is a linear combination of weighted values of the six variables, derived using Principal Component Analysis (PCA). The list of the six variables has been provided in the annex to this chapter, which also provides a detailed discussion on the PCA concept.

e. City: The city (Nairobi or Kisumu) in which the firms operate enters the models as a dummy variable with a value of one if the firm operates in Kisumu; otherwise zero. It shows up in the tables of results as *Kisumu.*

f. Log of operator's age: Also a continuous variable, the log of the age of the operators are used in the regression models and it is represented in the tables of results as *log_dage*.

g. Sex of operator/director: Represented in results by *female*, sex also enters the regression models as a dummy variable with a value of one when the operator is a female, otherwise zero.

h. Education of operator: This variable is represented in the table of the results by *above_basic_sch* and enters the regression models as a dummy variable with a value of one when the operator has more than primary (or basic) education, otherwise zero.

i. Marketing and administrative orientation of operator: Whether the operator has a business card or not is used as a proxy measure for the marketing and administrative orientation of the operator/director. Represented in the tables of results as *No_bus_card*, it is also a dummy variable which takes a value of one if the operator does not have a business card and zero if otherwise.

j. Ownership structure: This is a discrete variable which enters the regression models with a value of one if the firm is a sole proprietorship, otherwise zero and it is represented in the results as *Sole*.

An additional qualification regarding the model is worth mentioning, and that is, the categorisation of firms into formal and informal sectors does not enter any of the regression equations. The reason is that that variable perfectly predicts the probability of a formal sector firm having invested in machines and advanced country machines; thus, it assumes the

answer which I would like to test. It is also highly correlated with other explanatory variables particularly *firmsize* (Table 8.6 in the annex). Indicators for the clusters and registration status of the firms also do not enter the equations because they are also highly correlated with *No_bus_card and/or firmsize.* This is done mainly to reduce the impact of multicollinearity of the regressors while there is an added advantage of helping to meet the minimum sample size requirement for the logit regression.

8.2.2 Estimation method and results

The parameters (β) of the regression equations are estimated using the maximum likelihood method. Table 8.3 in the annex to this chapter shows the regression results. Results on two variants of the regression models for having invested in machines and for having invested in a machine from a particular source (China, Kenya and advanced countries) are presented. Each equation is first estimated with only the log of the firm's age and its square, and in the second case, the other independent variables are included in each of the models. In order to satisfy the minimum sample-size requirement for logit regression, eight regressors are used in the regression at the second transition since the number of firms that passed from the first transition to the second transition is 80 as shown in Table 8.3. The eight regressors used represent the combination out of the ten that generally produces the best fit for the models based on Aikaike Information Criterion (AIC) and Bayesian Information Criterion (BIC). AIC and BIC favour the regression model/result with the lowest AIC and BIC values. With the sample size of 131 at the first transition, all the 10 variables listed above are included in the regression for this transition without compromising the minimum sample-size requirement. Robust standard errors based on the sandwich estimator of variance (StataCorp, 2009) are obtained for all the regression results reported in Table 8.3 in the annex. Below are the interpretations/ discussions of the results.

<u>*Firm age*</u>

From Table 8.3 in the annex to this chapter, the influence of firm's age in all the models with only the log of firm's age and its square generally do not differ from those with all of the other

independent variables. The table shows that the both *Agelog* and its square (*Agelog2*) are not statistically significant for a firm having investment in machines (columns 1 and 2) but are significant for the investment in machines from China (columns 3 and 4), investment in Kenyan machines (columns 5 and 6) and investment in advanced country machines (columns 7 and 8). This result suggests that age may not have much influence on a firm's decision to invest in machines but it is important for the choice between the various sources for those firms that have invested in machines. A plausible explanation for why age does not significantly affect the decision to invest in machines can be found in the total integration of machining work by the formal sector firms and the relatively high degree of outsourcing and specialisation in machining work in the informal sector clusters. No matter how young a formal sector firm may be, it has to invest in machines in order not to outsource machining work. For the informal sector firms, however, a relatively old firm may choose not to invest in machines but depend on other firms that supply machining services.

Except for investment in machines, the results also indicate that the age of the firm has statistically significant and quadratic relationship with the probability that a firm that has invested in machines will invest in machines from China, Kenya and advanced countries. For investment in Chinese machines, with *Agelog* having a positive sign and its square being negative implies that the probability of investing in Chinese machines on average increases with age up to a given point (about 4.5 years) and falls thereafter as shown in Panel B of Figure 8.6[37]. Similarly and as shown in Panel C of Figure 8.6, the probability of investing in Kenyan machines on average increases with age up to about seven years after which it begins to decline. Contrarily, as Panel D of Figure 8.6 portrays, the probability of investing in advanced country machines initially falls with age and start rising after the firm is about five years old, at around the same age at which the probability for investing in Chinese machines starts to fall.

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[37] Each panel in Figure 8.5 plots the predicted probability from the regression analysis against the log of the firms' age. Taking antilog of the log of firm's age at the optimum of each quadratic produces the actual age of the firm at the various optima. The log of the firm's ages at the respective optima are obtained by taking the first differential of equation 3 with respect to agelog (i.e. the slope of the function with respect to agelog), setting the resultant equation to zero and solving for agelog in the resultant equation.

Figure 8.6: Probability of adoption by the log of firms' age

A. Having a machine
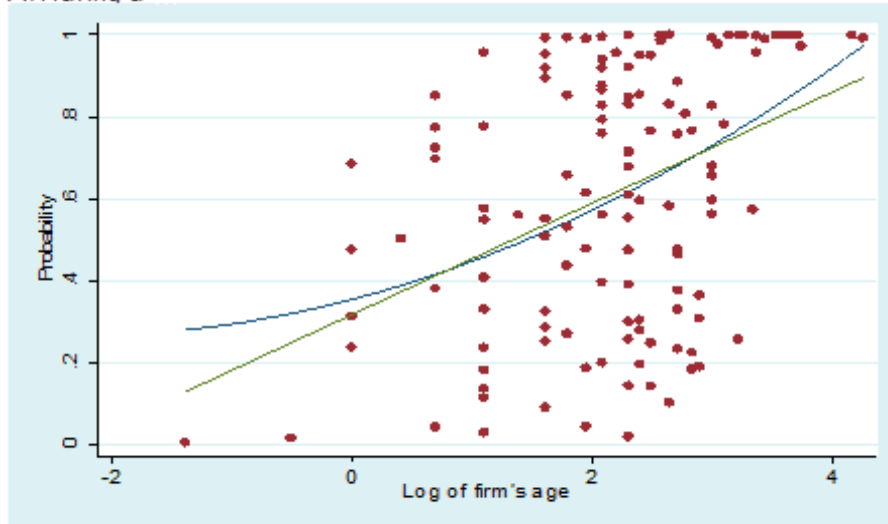
B. Having a Chinese machine
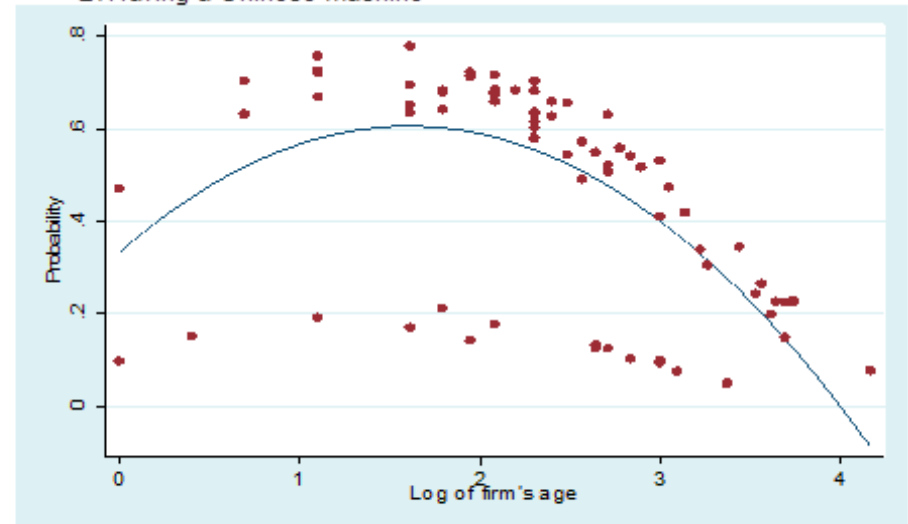
C. Having a Kenya machine
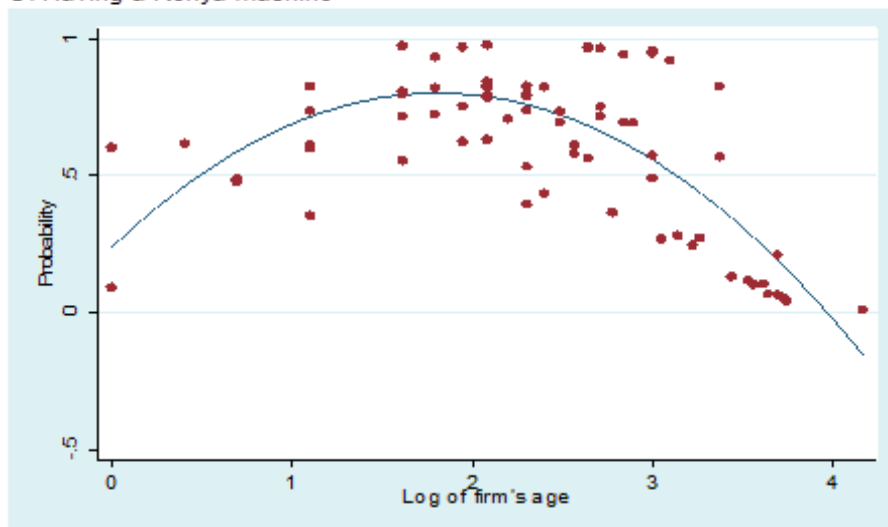
D. Having an advanced country machine
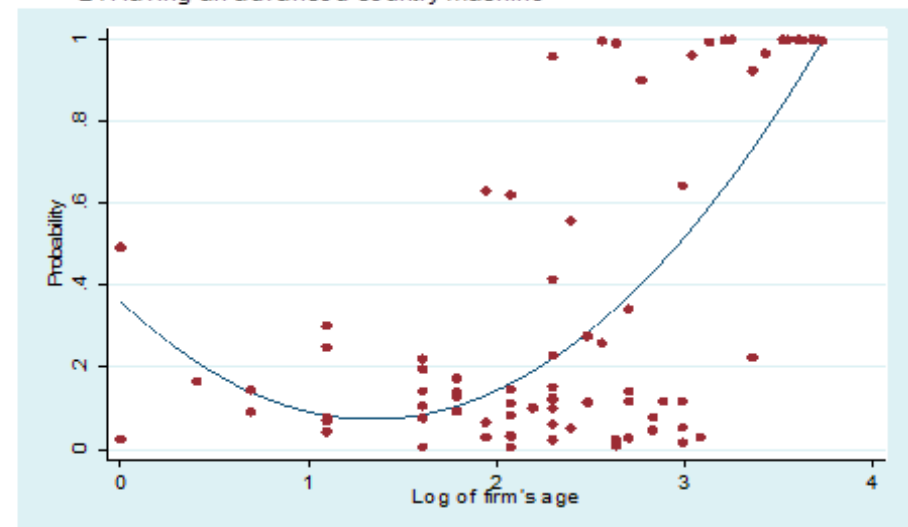
The above findings have three important implications concerning the role the Chinese and Kenyan technologies play in the furniture making industry. First, the similar effects of age on the probabilities of investing in the Chinese and Kenyan machines may suggest that generally the technologies from China and Kenya play similar roles and tend to complement each other as discussed earlier in this chapter. (Further discussion on this complementarity is provided in section 8.2.3).

Second, the role of these two technologies in the industry has been to lessen the entry barrier for new entrepreneurs wanting to enter into the furniture making industry or to enhance the degree of automation in the production processes of the firms particularly the informal sector firms. Many of such new operators especially those starting businesses in the informal sector are likely to be relatively poor and may not be able to afford the advanced country machines. As noted in Chapter 6, the informal sector firms invest in China and Kenya machines because of their low acquisition cost but with the wish to later diversify away from these machines to those from Europe. Additional information from the second round of interviews, specifically, a formal sector operator who employs about 90 workers adds more weight to this argument: "I started more or less as jua kali and I had only jua kali machines. But as the work progressed I was able to buy second hand machines from Europe. Now I have only two jua kali machines at my workshop" (Field interviews, 2012).

Third, the optimum age for the Kenyan machines is higher than that for the Chinese machines. This may be the result of the fact that Kenyan machines tend to last longer than the Chinese machines as noted in Chapter 6. It however also implies that the Chinese technology tend to serve as an entry mode to a greater extent than the Kenyan machines.

City (Kisumu)

This variable is statistically significant for investment in machines and negatively associated with the probability of a firm investing in machines. The variable is also significant in results for investment in machines from China and Kenya. It shows up with a positive sign in the

results for machines from China but a negative sign for machines from Kenya. This means that being in Kisumu is associated with a higher probability of investing in Chinese machines but with a lower probability of investing in Kenyan machines compared to the firms in Nairobi. As suggested earlier in section 8.1.3, firms in the Kibuye cluster seem to have embraced the Chinese technology more than those in Nairobi while those in Nairobi especially Gikomba cluster seem to still have relatively high confidence in the Kenyan machines. Unsurprisingly and as I pointed out earlier in Chapter 4 and in this chapter, I found many fabricators of the Kenyan machines in a close vicinity to the Gikomba furniture cluster while it was relatively more difficult to find any in Kibuye.

Firm size

Firm size is statistically significant for the decision to invest in machines but insignificant for the decision to invest in the technologies from a particular source. It has a positive sign in the results for investing in machines suggesting that as the size of the firm (in terms of the number of employees) increases the probability of investing in machines also increase. However, firm size is not significantly associated with the probability of investing in a machine from any of the three sources.

Access to finance

As mentioned in Chapter 7, bank loans (and loans from microfinance companies in the case of the informal sector firms) are not a popular means of financing machine acquisition. Rather, the firms tend to depend on internally generated funds. However, it should be noted that a positive relationship with financial institutions such as having a bank account and receiving short-term loans can make some important difference. The results show that access to finance (*Acc-Fin*) is statistically significant in the model for investment in machines but not for all the others. The coefficient in the results for investment in machines has a positive sign, which means that firms with high access to finance, as measured by *Acc-Fin*, have high probability of investing in machines. The intuitive explanation is that having a bank account for example may help a firm to save more, thus, with an account a firm may be able

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to accumulate savings faster to invest in machines. It may also simply reflect the fact that firms with bank accounts tend to have greater financial resources.

For firms deciding to invest in machines from a particular source, such relationship with financial institutions does not significantly influence the decision. This result appears counterintuitive and may have resulted from the fact that the measure for access to finance did not capture how much a firm is able to leverage from external sources. I must confess that I did not collect any data (including proxies) on the amount of loans the firms had taken from financial institutions in any given period. However, to the extent that firms do not depend much on external financing for acquiring machines suggests that the result would not change much even if the access to finance index or variable captured information about the volume of funds the firms are able leverage from financial institutions. Rather, what could make a major difference would be if the financial institutions could lend to the firms including the informal sector ones at a lower interest cost and with more flexible repayment terms than what they currently offer. Under such circumstances and assuming the influence of all other factors are muted, one could expect that the firms including those in the informal sector will invest more in advanced country machines, compared to the others.

Ownership structure

Ownership structure (*Sole)* is only statistically significant in the results for Kenya machines and advanced country machines. This means that being a sole proprietorship rather than a partnership or family-owned business is not significantly associated with the decision to invest in machines and also the decision to invest in Chinese machines. However, it is significantly associated with a higher probability of investing in Kenya machines and a lower probability of investing in advanced country machines. This finding is intuitively intelligible: Kenyan machines are very cheap, thus, an individual can more easily organise financial resources to purchase them while advanced country machines are very expensive, and hence, pooling resources from different individuals who may be relatives makes it easy to undertake such investment. Moreover, given that all the sole proprietorships are informal

sector firms and constitute about 85% of the informal sector firms (see Table 5.3 in Chapter 5), the results confirm the fact that the advanced country machines are relatively less attractive to the informal sector firms. This is not only because advanced country machines are relatively expensive but also important is the weak infrastructural condition in the various clusters particularly the Gikomba cluster. In other words, I least expect a typical informal sector firm particularly those in Gikomba to mount an advanced country machine in fire-prone, flood-prone and theft-prone environment even if the firm could afford such investment.

Operator's marketing and administrative orientation

As noted earlier in this Chapter, *No_bus_card,* which stands for an operator not having a business card is used to proxy the operator's marketing and administrative orientation. It has a positive coefficient and statistically significant result for investment in machines indicating that not having a business card increases the probability of investing in machines. This result appears counterintuitive and should be interpreted with care, as one would expect that not having a business card should be negatively associated with the probability of investing in machines. However, what it means is that there are a lot of informal sector firms whose operators have business cards but have not invested in machines as well as those whose operators have invested machines but have no business cards. The result is also plausible given that the dependent variable does not take into account the number of machines a firm has got especially considering the fact that a lot of the informal sector firms have invested in either one or two machines while all the formal sector firms have many machines.

For those firms that have invested in machines, not having a business card is significantly and positively related with the probability of investing in Kenya machines while it is significantly associated with a lower probability of investing in Chinese machines. Although not significant, it also reduces the probability of investing in advanced country machines. What this may suggest is that operators with relatively "modernised" marketing and administrative orientation prefer investing in Chinese and probably advanced country machines to investing in Kenyan machines. Generally, such operators may serve relatively

high income segments of the market which require high degree of precision, and of which the Kenyan machines may not be able to achieve.

Operator's level of education

Director's educational level (that is, having more than basic education) is not statistically significant in any of the results, indicating that the educational level of an operator does not significantly influence the decision to invest in machines and also machines from any of the three sources.

Operator's age and sex

The age and gender of the operator appear only in the regression model for investing in machines because the sample sizes for the others are relatively small with limited degrees of freedom. Age has a positive coefficient and it is significantly associated with the decision to invest in machines. Thus, older entrepreneurs tend to have investment in machines more than their younger counterparts. This result may be explained in the sense that older operators might have accumulated savings if they have been in their current business for a long time or from their previous vocation, which could be used for investing in machines. Moreover, older people generally tend to have better access to family resources or inheritance and wider social networks, all of which can be used to mobilise resource for investment in machines. The results however show that being a female operator has no significant relationship with whether a firm will invest in machines or not.

8.2.3 Bivariate/multivariate probit models for testing complementarity

In order to quantitatively test the complementarity between investment in Chinese machines and Kenyan machines, the regression equations for the second transition of the choice process depicted in Figure 8.5 is reestimated for having a Chinese machine and having a Kenyan machine but in a bivariate/multivariate probit model. The bivariate model starts with the idea that the error terms in the regression equations for two dichotomous variables (for example, in this case of this thesis, having a Chinese machine and having a Kenya machine)

are correlated (Greene, 2012). Hence, under normality assumption, the two variables are simultaneously modelled (Maddala, 1983). Since we have a third dichotomous dependent variable (i.e. having an advanced country machine), a generalised form of the bivariate model, that is, the multivariate probit model[38] is also applicable or may be more appropriate. I therefore reestimate the regression equations for the second transition using both bivariate probit models (results are reported in Table 8.4) and multivariate probit models (results reported in Table 8.5). For the bivariate models, the equations are estimated using the maximum likelihood technique while a simulated likelihood method is used for the multivariate model and robust standard errors are obtained for both results in a way similar to the previous regressions.

Several methods such as simple Chi-square test and simple (product moment) correlation analysis can be used to examine this relationship. What makes the bivariate/multivariate probit models most attractive for this study is that they allow for the calculation of tetrachoric correlation coefficient, examining its significance and making the tetrachoric correlation coeficient conditional on a set of independent variables that may confound the relationship between the two variables (Greene, Undated; Greene, 2012). The tetrachoric correlation coefficient is the correlation coefficient for two binary variables calculated as if the variables involved were continuous variables, based on the idea that the values of both variables are respectively determined by latent continuous variables (Uebersax, 2006). A significant positive coefficient suggests that investment in the Chinese machines and Kenyan machines are complementary and statistically significant.

The above test is also a test for exogeneity of all the dependent variables, thus, serving as robustness check on the logit models. Thus, although complementarity between investment in Chinese and Kenyan machines is of the most concern in this section, I use the same approach to diagnose the exogeneity and the extent of substitutability (negative complementarity) between investment in Kenyan machines and advanced country machines and then between advanced country machines and Chinese machines.

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[38] For further insight, see Greene (2012) and Cappellari and Jenkins (2003)

Tables 8.4 and 8.5 reports the conditional tetrachoric correlation coefficients for all the three relationships (that is, between China and Kenya, that between Kenya and advanced countries, and that between China and advanced countries). From Table 8.4, the coefficient for China and Kenya (0.025) is positive suggesting that investment in Chinese machines and Kenyan machines drive each other which supports the complementarity argument made earlier. However, the coefficient reported for investments in Chinese and Kenyan machines in the multivariate model, which controls for the influence of investment in advanced country machines, is negative (-0.027). It is important to note that the coeffients from the two models are both insignificant (even at 10%), suggesting that the complementarity between investments in Chinese and Kenyan machines is not strong and these two variables are exogeneous to each other. The reason why this complementarity appears weak in the data may stem from the existence of the market based cooperation and specialisation (discussed earlier in this chapter in Section 8.1.1) with regards to investment in machines in the informal sector. For example, a firm that has a Kenyan lathe machine may not invest in a planer but buy the services of another firm with Chinese planer, in which case the investment in these two machines are complementary but with across-firm effect. That is, complementarity between the Chinese and Kenyan machines does not happen only at the firm level as captured by the quantitative data but also across firms. Further quantitative data may be needed to test the degree of complementarity across firms. However, based on the qualitative data presented in Section 8.1.1, my conjecture is that the across-firm complementarity will be positive and high so that the total complementarity may be positive and perhaps statistically significant.

The results further show that the tetrachoric correlation coefficient for investment in Kenyan and advanced country machines is negative but also insignificant at 10% for both the bivariate and multivariate models. Similarly, although it is negative, the conditional tetrachoric coefficient for investment in Chinese and advanced country machines is also insignicant at 10% for the bivariate model and 5% for the multivariate model. The test for the joint exogeneity of the three dependent variables in the multivariate model shows

insignificant relationship, even at 10% significance level. That is, the dependent variables are jointly exogeneous in statistical terms suggesting that overall there is a weak association between investment in the advanced country, Chinese and Kenyan machines.

The above results indicate that it is less likely that a firm will subsitute advanced country machines for Chinese or Kenyan machines. The implication is that though the informal sector firms hope to move away from Kenyan and Chinese machines to the high quality advanced country machines, the firms on average may not be able to achieve this. Such a stalemate may bolster investment in Kenyan and Chinese machines of the type described in this study and may reinforce the complementarity between Chinese machines and Kenyan machines, *ceteris parabus.* Or at best, investment in advanced country machines may occur in tandem with investment in machines from China, Kenya and probably other sources such as India and other emerging economies. Thus, they may not be able to completely move away from the Chinese and Kenyan machines. The caveat however is that this prediction is based on cross sectional data while the relationship between the firms' adoption of the different technologies is largely dynamic, hence, a panel data may produce a more robust prediction. Moreover, like the complementarity, the substitutability may also have across-firm effect.

8.3 Conclusion

This chapter has found that penetration of Chinese technology is relatively high in the informal sector compared to the formal sector (over two times higher than the formal sector). Moreover, Kenyan (jua kali fabricated) machines are also popular, even more than the Chinese machines particularly for the informal sector firms while the formal sector firms mainly rely on advanced country machines.

The main factors that may account for these patterns include: the characteristics of the technology (particularly acquisition cost, durability and functionality); the target market of the firms; infrastructural conditions in the firms' premises or clusters; and the returns on investment in the technologies. Also important are the modes of acquisition within the arm's length market trade by which the technologies are mainly transferred or diffuse to the firms.

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Moreover, the firm and operator characteristics such as the age of the firm, access to finance, and ownership structure are important. Particularly, the age of the firms has been found to exhibit a nonlinear effect on the adoption of technologies from the three sources. Increases in a firm's age initially increases the probability of investing in Chinese and Kenyan machines but the probabilities decrease after a given age (4.5 years for Chinese machines and 7 years for Kenyan machines). The reverse relationship is true for advanced country machines, of which the optimum occurs at age 5. The major implication is that Chinese and Kenyan technologies have improved new firms' access to machines, particularly those in the informal sector, reducing entry barrier into furniture making industry while enhancing automation in the industry. The effect is more crucial for poor entrepreneurs who want to avoid looking for non-existing wage employment in the formal sector. Also worth noting is the potential complementarity between the adoption of machines from China and Kenya in removing the entry barrier..

The next chapter concludes the thesis by providing an overall summary of the findings and an examination of the implications of the findings in the light of the development imperatives of Kenya while highlighting the implications for policy, the literature and further research.

Annex to Chapter 8: PCA and regression results

8A Measuring access to finance using principal component analysis

Principal component analysis (PCA) is a nonparametric statistical tool, which can be used to create an index to represent an unobservable variable (a variable that is not directly measurable) from a set of observed variables (Shlens, 2009; Wall, 2006; Cahill and Sanchez, 2001; Ram, 1982). It is therefore a good tool that can be used to measure firm's access to finance, which is also not directly measured or observed. To do this, the firms were asked to answer six questions, of which each gives some indication about the firms' level of access to finance from financial institutions including micro finance institutions. The questions were as follows:

    a. Does your firm have a bank account or save with a micro finance institution?

    b. How many of such accounts does your firm have?

    c. Have you applied for any loan for your business in the last two years?

    d. Have you received any loan for your business from a bank or micro finance institution in the last two years?

    e. How many times in the last two years have you received such loans?

    f. On a scale of 1-7 (where 1 means no access to finance and 7 means very high access to finance), how do you rate your access to finance?

PCA works with the principle that the unobserved variable, also called the latent variable, is correlated with a set of directly measured variables (in this study the variables measured using the above six questions) by examining the correlations between these observed variables (Cahill and Sanchez, 2001). The procedure reduces the information in the many variables by decomposing the variance in the data into factors or components. Each component is the sum of each of the observed variables multiplied by its weight, which is the proportion of the variance in the data accounted for by each of the observed variables. One of the components is usually chosen to be the index measuring the observed variables based on the criteria that the chosen component should have the highest eigenvalue or

produces the highest explanation of the variance in the data. This component is called the First Principal Component. Table 8.3 shows the results of PCA indicating the first component explains 68% of the variance in the data with an eigenvalue of 4.084. The Kaiser-Meyer Olkin (KMO) test is applied to examine the robustness and sampling adequacy of the PCA performed on the data, which produces an overall correlation of 0.812 shown in Table 8.2. The rule is that if the KMO is more than 0.5 then PCA analysis can be performed on the data to create the desirable index and this rule is satisfied by the data.

Table 8.1: Results of principal component analysis

Number of obs.	131
Number of comp.	6
Trace	6
Rho	1.000

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	4.084	3.001	0.681	0.681
Comp2	1.083	0.684	0.181	0.861
Comp3	0.399	0.208	0.066	0.928
Comp4	0.191	0.059	0.032	0.959
Comp5	0.131	0.019	0.022	0.981
Comp6	0.112		0.019	1.000

Principal components (eigenvectors)

Variable	Comp1	Comp2	Comp3	Comp4	Comp5	Comp6	Unexplained
q13a	0.355	0.602	-0.006	0.677	-0.115	0.201	0
q13b	0.422	0.357	0.311	-0.620	0.2138	0.410	0
q13c	0.417	-0.276	-0.640	0.080	0.565	0.122	0
q13d	0.423	-0.407	-0.149	-0.075	-0.733	0.301	0
q13e	0.364	-0.475	0.679	0.318	0.251	-0.126	0
q13f	0.460	0.209	-0.101	-0.209	-0.145	-0.819	0

Table 8.2: Test for sampling adequacy of the PCA

Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy

Variable	KMO
q13a	0.802
q13b	0.831
q13c	0.829
q13d	0.765
q13e	0.820
q13f	0.827
Overall	0.812

8B Regression results for sequential logit model and bivariate/multivariate probit models

Table 8.3: Regression results for sequential logit models

INDEPENDENT VARIABLES	Having machines		China		Kenya		Advanced countries	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Agelog	0.223	1.742	1.342*	1.222*	3.001**	3.973***	-2.285**	-2.937*
	(0.431)	(1.142)	(0.709)	(0.725)	(1.323)	(1.151)	(0.970)	(1.729)
Agelog2	0.108	-0.502	-0.353**	-0.406*	-0.832***	-1.027***	0.852***	0.925*
	(0.109)	(0.323)	(0.171)	(0.218)	(0.285)	(0.288)	(0.230)	(0.502)
Kisumu		-1.140*		2.488***		-2.548**		1.642
		(0.659)		(0.940)		(1.032)		(1.025)
Firmsize		0.207*		-0.00174		0.00858		0.0328
		(0.109)		(0.00971)		(0.00960)		(0.0444)
Acc_Fin		0.750***		-0.0606		-0.0853		0.180
		(0.189)		(0.138)		(0.153)		(0.213)
Sole		-0.783		-0.0773		1.373*		-3.170***
		(0.694)		(0.566)		(0.719)		(0.804)
Female		1.155						
		(1.309)						
log_dage		2.434**						
		(1.160)						
above_basic_sch		0.565		-0.0502		-0.194		1.303
		(0.486)		(0.540)		(0.692)		(0.894)
No_bus_card		2.967***		-2.276**		2.208**		-1.887
		(0.805)		(0.917)		(0.996)		(1.292)
Constant	-0.594	-10.88**	-1.911**		-1.303	-3.455**	-0.656	1.698
	(0.488)	(4.330)	(0.766)		(1.425)	(1.416)	(1.107)	(1.892)
Pseudo R-square	0.0585	0.3724	0.0255	0.1807	0.1611	0.2847	0.279	0.5729
Observations	131	131	80	80	80	80	80	80

Note: (1) Robust standard errors in parentheses (2) *** p<0.01, ** p<0.05, * p<0.1

Table 8.4: Results of bivariate probit models and tetrachoric (rho) correlation

INDEPENDENT VARIABLES	China and Kenya				China and Adv. countries				Kenya and Adv. Countries			
	(1)		(2)		(3)		(4)		(5)		(6)	
	China	Kenya	China	Kenya	China	Adv. Countries	China	Adv. Countries	Kenya	Adv. Countries	Kenya	Adv. Countries
Agelog	0.924	1.782**	0.708	2.411***	0.927*	-1.409**	0.700	-1.800	1.780***	-1.477**	2.401***	-1.707*
	(0.562)	(0.699)	(0.444)	(0.672)	(0.555)	(0.617)	(0.437)	(1.101)	(0.673)	(0.623)	(0.660)	(1.031)
Agelog2	-0.293**	-0.501***	-0.233*	-0.628***	-0.294**	0.518***	-0.231*	0.573*	-0.500***	0.540***	-0.625***	0.535*
	(0.128)	(0.152)	(0.129)	(0.166)	(0.128)	(0.141)	(0.128)	(0.299)	(0.148)	(0.146)	(0.164)	(0.277)
Kisumu			1.462***	-1.521***			1.445***	0.924			-1.533***	0.970*
			(0.526)	(0.552)			(0.528)	(0.566)			(0.558)	(0.565)
Firmsize			-0.00187	0.00509			-0.00190	0.0169			0.00504	0.0158
			(0.00558)	(0.00579)			(0.00565)	(0.0253)			(0.00576)	(0.0228)
Acc_Fin			-0.0311	-0.0514			-0.0303	0.0940			-0.0514	0.0958
			(0.0808)	(0.0920)			(0.0802)	(0.0919)			(0.0924)	(0.0932)
Sole			-0.0490	0.808*			-0.0462	-1.842***			0.807*	-1.821***
			(0.344)	(0.413)			(0.339)	(0.463)			(0.414)	(0.462)
above_basic_sch			-0.0100	-0.0914			-0.00525	0.784*			-0.0875	0.782*
			(0.324)	(0.391)			(0.321)	(0.421)			(0.390)	(0.437)
No_bus_card			-1.309***	1.311**			-1.289**	-1.098*			1.319**	-1.167*
			(0.500)	(0.515)			(0.502)	(0.641)			(0.525)	(0.653)
Constant	-0.435	-0.729		-2.073***	-0.433	-0.317		1.030	-0.730	-0.279	-2.062***	1.002
	(0.612)	(0.759)		(0.804)	(0.599)	(0.691)		(1.207)	(0.718)	(0.687)	(0.793)	(1.130)
rho	-0.1262214		0.0254766		-0.0113023		-0.2062326		-0.4278474		-0.1806312	
LR test [Chi2(1)] for rho	0.422161		0.014605		0.002936		0.637676		4.10598		0.428391	
P-value for Chi2	0.5159		0.9038		0.9568		0.4246		0.0427		0.5128	
Observations	80	80	80	80	80	80	80	80	80	80	80	80

Note: (1) Robust standard errors in parentheses (2) *** p<0.01, ** p<0.05, * p<0.1

Table 8.5: Multivariate probit regression results and tetrachoric (rho) correlation

INDEPENDENT VARIABLES	China (1)	Kenya (2)	Adv. Countries (3)
Agelog	0.689	2.363***	-1.984**
	(0.434)	(0.586)	(1.004)
Agelog2	-0.230*	-0.618***	0.628**
	(0.128)	(0.151)	(0.277)
Kisumu	1.394***	-1.569***	0.964*
	(0.518)	(0.557)	(0.508)
Firmsize	-0.002	0.005	0.012
	(0.006)	(0.006)	(0.014)
Acc_Fin	-0.032	-0.056	0.205
	(0.083)	(0.091)	(0.136)
Sole	-0.045	0.808*	-1.940***
	(0.340)	(0.413)	(0.478)
above_basic_sch	0.004	-0.054	0.668*
	(0.321)	(0.383)	(0.363)
No_bus_card	-1.262**	1.333**	-1.166*
	(0.489)	(0.520)	(0.623)
Constant		-2.019***	1.369
		(0.728)	(1.111)
Observations	80	80	80
rho21_China&Kenya	-0.027		
	(0.180)		
rho31_China&Adv	-0.355*		
	(0.192)		
rho32_Kenya&Adv	-0.409		
	(0.299)		
LR Test (Ho:rho21=rho31=rho32=0)	Chi2	3.637	
	P-value	0.303	

Note: (1) Robust standard error in parentheses (2) ***p<0.01, **p<0.05 and *p<0.1

8C. Correlation analysis for checking multicollinearity between independent variables

Table 8.6: Correlation between independent variables

	Agelog	Kisumu	Firmsize	Acc_Fin	Sole	Female	log_dage	above_basi	No_bus_ca	informality	Registratio	Ngong	Gikomba	Kibuye
Agelog	1													
Kisumu	-0.039	1												
Firmsize	0.418	-0.214	1											
Acc_Fin	0.235	-0.157	0.502	1										
Sole	-0.274	0.052	-0.497	-0.185	1									
Female	-0.210	0.019	-0.006	-0.105	0.074	1								
log_dage	0.529	-0.137	0.456	0.213	-0.316	0.073	1							
above_basi c_sch	-0.001	-0.232	0.262	0.313	-0.074	0.047	0.152	1						
No_bus_car d	-0.044	0.661	-0.333	-0.293	0.106	-0.003	-0.262	-0.261	1					
informality	0.502	-0.246	0.758	0.411	-0.677	-0.007	0.561	0.246	-0.373	1				
Registration	0.357	-0.316	0.513	0.426	-0.418	-0.014	0.447	0.225	-0.493	0.629	1			
Ngong	-0.336	-0.478	-0.214	-0.014	0.379	0.012	-0.159	0.103	-0.692	-0.350	0.047	1		
Gikomba	0.003	-0.282	-0.190	-0.185	0.089	-0.029	-0.163	-0.098	0.475	-0.206	-0.286	-0.400	1	
Kibuye	-0.039	1.000	-0.214	-0.157	0.052	0.019	-0.137	-0.232	0.661	-0.246	-0.316	-0.478	-0.282	1

CHAPTER 9 : CONCLUSION

9.0 Introduction

This chapter concludes all the discussions in this thesis. It first presents a summary of all the discussions in the previous chapters after which the optimality of choice in favour of any of the technologies studied in this research are discussed in the light of Kenya's development imperatives. The chapter also discusses the policy implications of the findings. Moreover, the implications of the findings for the literature in the subject area of the thesis are also discussed. Lastly, the author's reflections on the whole research process are outlined including ideas for further research.

9.1 Summary

Chapter 1 noted that China has emerged as the leading source of the importation of capital goods into Kenya and Sub Saharan Africa as a whole, which before the noughties depended largely on advanced economies for capital goods. Thus, there is a disruption of the pattern of technology transfer to Sub Saharan Africa including Kenya. A significant aspect of this disruption is that capital goods are being developed within a developing country (China) and for other developing countries. This disruption is however only one aspect of the diverse and global, economic and geopolitical implications of China's phenomenal rise in economic power. It was further noted that while research into several aspects of the implications of China's rise are no longer trailblazing, very little is known about the impact of the transfer of technologies, and in particular capital goods, from China to other developing countries.

Filling such a research gap is very critical for industrial and development policy in developing countries, particularly against the backdrop that a section of the literature emphasises the inappropriateness of technologies from advanced countries for operating conditions in developing countries. The literature argues that advanced country technologies are inappropriate for developing countries because they target high income consumers, are highly capital and skill intensive offering limited opportunities for employment and are for

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realising scale economies with great reliance on sophisticated infrastructure. Hence, they are less amenable for promoting poverty reduction and equitable distribution of income. At the same time, the theory of induced technical change asserts that demand, factor endowment, path dependence and other socioeconomic factors influence the direction of technical change. The implication is that technologies produced in different contexts may possess different characteristics and their application may lead to different development trajectories. Given this background, the key issue that motivated this research was whether the impact of Chinese technology on development in other developing countries would differ from that of the advanced country technologies. In order to explore this issue, three main research questions were posed in Chapter 1, and for the sake of empirical tractability, the furniture-manufacturing industry in Kenya was strategically chosen to find answers to the research questions, which were:

1. How distinctive are Chinese technologies used in Kenya's furniture making industry with respect to their technical and economic/social characteristics?

2. How are the Chinese technologies transferred from China to the Kenyan firms compared to the advanced country technologies?

3. To what extent have the firms adopted the Chinese technologies, compared to those from advanced countries and Kenya and what factors influence the adoption?

Having narrowed the scope of the study to Kenya, Chapter 2 sought to provide an overview of Kenya's development situation. The overview depicted the recent development state of Kenya while highlighting the historical antecedents. It was noted in the chapter that Kenya is a low income economy whose per capita GDP has stagnated over most of the years of political independence, negatively affecting socioeconomic conditions in the country. High levels of unemployment particularly among the youth, poverty and inequality have become attendant features of the economy. The informal sector of the economy is very large accounting for about 80.5% of employment in Kenya. Infrastructure especially power supply is poorly developed. At the same time, indigenous technology and innovative capacity is generally low leading to high dependence on imported technology. The chapter further

alluded to the fact that the undesirable state of affairs cannot be disassociated from the general lack of robust political institutions that are responsible for policy configuration, thus, affecting the socioeconomic development of the country.

Chapter 3 reviewed literature related to the subject matter of the three research questions. It was shown in the chapter that technology has been variously defined in the literature and that various authors have used the term to refer to different but related concepts in time. Generally, the term can stand for an artefact (or collection of artefacts), techniques (or process), organisation and even network forms between organisations.

The rest of the discussion in the Chapter 3 centred around three main themes: technology choice; sources of technical change, under which biases in technical change and the theory of induced innovations were discussed; and technology transfer. The review on technology choice highlighted the neoclassical framework for technology choice and its shortcomings, which gave impetus to the evolution of appropriate technology as a development paradigm. The basic conclusion from the neo classical framework is that with a given production function, relative factor price solely determines technology choice such that capital-endowed countries will select capital-intensive techniques while labour-endowed countries will select labour- intensive techniques. The literature review however showed that while relative factor price is an important determinant of technology choice, there are other important factors such as scale, income levels, characteristic of the decision maker, the type of products/services to be produced, access to finance, and imperfect product and factor markets. These other factors are important because they can significantly alter the choice based just on the relative factor price. Thus, the choice determined in the neoclassical framework can be inappropriate in the presence of efficient and appropriate ones.

Chapter 3 also showed that path dependence in technical change and differences in market demand and relative factor prices across different countries can explain the existence of inappropriate technologies. These factors can produce bias in technical change with the implication that technologies produced in a given socioeconomic context may be

inappropriate for a different socioeconomic context. The same factors underpin the theory of induced innovation/technical change. This theory suggests that technical change does not only result from independent activities that take place in the arms of science but market demand, relative factor prices and the path-dependent nature of technical change are more important.

The literature review also highlighted the different channels by which technology can be transferred. The major channels identified in the literature were arm's length trade, direct investment and governed network structures that characterise value chains. It was also noted the factors that influence the choice of a transfer mode include the characteristics of the technology being transferred, and the characteristics of the transferor and transferee and the socioeconomic and political conditions of their countries.

Based on the literature reviewed in Chapter 3, Chapter 4 presented a conceptual framework that guided the analyses of the empirical data. The meaning of technology in the framework was restricted to artefacts, that is, machines and equipment. A salient aspect of the framework also worth reiterating here is that the factors, which influence technology choice, can also determine the choice of a transfer mode. Moreover, the choice of technology can influence the choice of the transfer mode whereas the availability or accessibility of a particular mode can also influence technology choice.

Chapter 4 also dealt with the research method/approach adopted for the study. The mixed research methods approach, which combines elements of both quantitative and qualitative research methods, was used. The approach for answering each research question however differed with regards to the degree of reliance on quantitative and qualitative data. The approach for the third question was largely quantitative compared to the approach for the first question and more so when compared to the approach for the second question, which was qualitative to a great extent. The data collection was done in two rounds: The first largely involved collecting quantitative data using a questionnaire from 131 firms operating in four clusters in Nairobi and Kisumu. The clusters were Industrial Area, Ngong', Gikomba and

Kibuye. The second involved collecting largely qualitative data about the technologies and their transfer modes from 41 firms who were purposively selected from those interviewed in the first round. Four main types of woodworking machines were considered in the second round of the interviews, that is, the planer, band saw, saw bench and lathe. Other respondents who were also interviewed included sales and distribution firms of the technologies and fabricators of the Kenyan machines who also repair the other machines.

Chapters 5 to 8 presented information based on the analyses of the field data. However, unlike Chapters 6 to 8, the analysis in Chapter 5 did not directly answer any of the three research questions. The chapter examined in detail the entrepreneurial and business profile of the firms interviewed which involved exploring the characteristics of the firms and their operators and the clusters in which they operate. Among the many factors considered were business registration and tax obligation status of the firms, the age of the firms, ownership structure, products and target markets, linkages with other firms, employment, and housing and infrastructural conditions in the clusters. The chapter also discussed the characteristics of the operators such as the age, sex, education and the ethnic background of the operators.

An important conclusion from Chapter 5 was that the Industrial Area firms are distinctive from the others and could be described as formal sector firms while the degree of informality is high for firms in the other clusters especially the Gikomba and Kibuye clusters. However, the Ngong' cluster tends to exhibit (though to a limited extent) some of the characteristics of the formal sector firms especially with respect to middle income consumer's patronage for their products and education level of the operators. However, the firms in the Ngong' cluster are more similar to those in Gikomba and Kibuye clusters than they are to the formal sector firms (Industrial Area firms). Hence, the discussions in Chapters 6 to 8 largely used a categorisation of the firms in which the Industrial Area firms and the remaining three clusters (Ngong', Gikomba and Kibuye) were respectively considered as formal and informal sectors.

It was however noted in Chapter 5 that the difference between the Ngong' cluster and the other two informal sector clusters lend credence to the belief in the literature that informality

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is a continuum with varying degrees among firms, highlighting the heterogeneous nature of firms operating in informal sector. It was emphasised that such heterogeneity can occur among firms in the same line of activity as in the case of the furniture-manufacturing firms studied in this research. The subsections that follow summarise the main findings of the research for each of the three basic research questions.

Research question 1

The information presented in Chapter 6 and parts of Chapter 7 sought to provide the answer to research question 1, which is about the distinctiveness of Chinese technologies in terms of the technical and economic/ social characteristics. Chapter 6 compared the Chinese machines to the advanced country and Kenyan machines on durability, quality (defined in terms of precision and flexibility of functions), run and robustness, scale, acquisition and maintenance costs, and skill requirements. It was shown that with regards to durability, run and robustness, the Chinese machines found in Kenya's furniture making industry lag behind the advanced country machines. However, they are better than the Kenyan machines in the area of precision and flexibility of the functions while the Kenyan machines last longer than the Chinese machines.

Chapter 6 also showed that the scale of the Chinese machines found in Kenya's furniture-making industry is lower than the other two especially against the advanced country machines. In order to take advantage over their precision and flexibility, the Chinese machines particularly the planers have been locally modified by some of the informal sector operators. The modification involves changing essential parts especially the motor, which is done at an additional cost to the cost of acquiring the machine. Such modification improves the run and output level but not up to those of the advanced country machines. The Chinese machines also break down more regularly; however, the maintenance cost in addition to the modification costs still do not make the Chinese machines financially less attractive than the advanced country machines for the informal sector firms. The reason is that the Chinese machines are far cheaper than the advanced country machines, which is still true even when we control for the longer lifespan of the advanced country machines: The annual capital

consumption per worker for the advanced country planer, for example, is about three times and five times those of the Chinese and Kenyan planers respectively. Thus, the Chinese machines on the other hand are more expensive than the Kenyan machines. However, the relatively higher precision and flexibility of the Chinese machines make them (especially the planer) attract the informal sector firms while the advanced country machines are generally unaffordable for the informal sector firms.

Chapter 7 presented analyses of the production coefficients for the different technologies. Using the planer for illustration, the chapter also estimated the likely returns on investment in these technology types. It was found that the Chinese machines (both original and modified) may be inefficient compared to the advanced country and Kenyan machines if the machines operate at rated capacity utilisation. Similarly, the analysis on benefit-cost ratio (BCR) – an indicator of returns – showed that the relative returns on investment in the advanced country machines and Kenyan machines are likely to be better than the Chinese machines at rated capacity levels for both formal and informal sector firms.

However, it was noted in Chapter 7 that actual daily production rate is usually lower than the rated capacity levels; hence, the production coefficients and return on investment indicators were accordingly re-estimated for actual daily production rate. At this capacity utilisation, it was found that the Chinese technology is likely to be as efficient as the advanced country while the Kenyan machines still appears to be more efficient than the Chinese machines. The BCRs at this production level showed that only the Kenyan and the modified Chinese machines are likely to be profitable in the informal sector, justifying the need for the modification. For the formal sector, however, all investments including the advanced country machines are viable although the modified Chinese planer may yield higher returns compared to the others. Given that the formal sector firms are much larger than their informal sector counterparts, these results highlight the importance of scale considerations in a technology choice. That is, in small markets and for small manufacturing establishments, the advanced country technologies appear less attractive than in the formal sector or larger markets. The relatively high profitability of investments in the formal sector also reinforces

the need for formalising the informal sector to the best degree possible. However, these conclusions should be treated with caution given that the indicators were developed with some restrictive assumptions (as was laid out in the annex to Chapter 7) because of the lack of adequate empirical data.

Another important finding from Chapter 7 was that the Kenyan technology does not only seem to offer relatively high efficiency and return but it is the most labour intensive, followed by the Chinese machines. The apparent superiority of the Kenyan machines over the others should however be hedged against the fact that they produce lower quality output than the other machines while quality difference between the Chinese and advanced country machines are very minimal, as Chapter 6 showed. Chapter 6 also showed that though the advanced country machines are slightly more complicated to use and repair, the skill intensity of the three technologies generally do not differ much. Moreover, skills are available locally for where the little differences appear to exist.

Research question 2

Research question 2 focuses on the modes by which the technologies are transferred to the firms. A section of the analyses in Chapter 7 sought to address this research question. Of the modes of transfer identified in the literature (arm's length trade, FDI, joint venture and governed GVC network structures), it was found in Chapter 7 that arm's length trade is the main channel by which the three technologies reach the firms. This is a truism for the informal sector firms because they lack the capacity to engage in any other transfer method. For instance, no foreign direct investment could possibly go to the informal sector and they also do not participate in global value chain of furniture manufacturing. Similarly, the formal sector firms do not have any meaningful participation in global value chain for furniture and only one of the 20 formal firms interviewed in the first round of the survey can be classified as foreign direct investment.

It was however found that the mode of acquisition within the arm's length trade differs across the three technology types and between the informal and formal sectors. The firms acquire

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the Chinese machines from sales and distribution firms in the domestic market while for advanced country machines the formal sector firms may purchase them directly from foreign markets. For second-hand advanced country machines, however, the firms buy some locally, which is the only way by which an informal sector firm can purchase second-hand machines from advanced countries. Obviously, the transfer processes for Chinese and advanced country machines involve importation. For Chinese machines, the domestic sales and distribution firms do the importation, while for advanced country machines, the formal sector firms also buy directly from foreign markets especially in the case of brand new machines. For Kenyan machines, the firms purchase them directly from the local fabricators.

It was also found that a closely related issue to the mode of acquisition is the financing options and payment terms available to the firms. While the firms including those in the formal sector mainly rely on internal funds, the payment terms available for acquiring machines differ slightly between Kenyan machines and the imported machines. Purchasing a Chinese or an advanced country machine mainly involves making outright payment of the total cost of the machine. However, Kenyan machines can be purchased through a flexible payment system where the firms are allowed to make a deposit and then pay the remaining balance in instalments over a short period of time, usually in three months. This flexible payment system makes the Kenyan machines attractive to informal sector firms.

Research questions 3

Chapter 8 was dedicated to finding the answer to research question three. The analysis in the chapter showed that the penetration of the Chinese technology is relatively high in the informal sector compared to the formal sector (over two times higher than the formal sector). Moreover, Kenyan machines are also popular, even more than the Chinese machines particularly in the informal sector while the formal sector firms mainly rely on advanced country machines. The main factors that may account for this pattern of adoption include the characteristics of the technology (particularly acquisition cost, durability and functionality), the target market of the firms, housing and infrastructural conditions in the clusters.

Chapter 8 further showed that differences in the firms' characteristics, especially with respect to ownership structure, access to finance (of which additional and qualitative evidence was presented in Chapter 7) and the age of the firms also have important implications for adopting a technology from a particular source. An interesting finding was that the age of the firms is nonlinearly related to the adoption of technologies from the three sources. An increase in a firm's age is initially positively associated with the probability of investing in Chinese and Kenyan machines, but the probabilities start to decrease after a given age (4.5 years for Chinese machines and 7 years for Kenyan machines). Conversely, the probability of investing in advanced country machines decreases with the age of the firm up to age 5 before it increases with the firm's age. The major implication is that Chinese and Kenyan technologies have improved the firms' access to automated machines or reduced entry barrier into the furniture making industry particularly for the informal sector firms. Many of the informal sector firms especially new ones cannot afford the advanced country machines. The study also found that investment in Chinese and Kenyan machines appear to be complementary particularly among the informal sector firms. The complementarity is not confined to the investment decisions of a firm but also across firms in the informal sector operating within a cluster. The complementarity suggests that, to some degree, these two technologies depend on each other in enhancing access to automation in the furniture making industry in Kenya.

9.2 Optimality of technology choice and policy implications

9.2.1 Optimality of technology choice and Kenya's development imperatives

The aim of this section is to examine the main findings of the study in the light of Kenya's development ills, thus, highlighting the extent to which each technology type may be appropriate for alleviating the development problems. The different technologies offer some advantages but with varying implications for desirable development outcomes needed for Kenya especially in the wake of high unemployment particularly among the youth, high inequality and extreme poverty. As was mentioned in Chapter 2, about 43% of Kenya's

population still live on less than US $1.25 per day, with the Gini coefficient (an income inequality indicator) for Kenya being as high as 0.48. Chapter 2 further showed that the official unemployment rate is 12.7%, which shoots up to 40% when discouraged workers are considered as part of the unemployed, with the youth constituting 64% of the unemployed.

Of the three technologies studied in this research, the one that will create more employment would be suitable for Kenya given the high unemployment level, all things being equal. As noted in the above summary of findings, the Kenyan (locally/jua kali fabricated) machines tend to have the lowest capital-labour ratio, which suggests that the use of Kenyan machines should create the highest employment opportunities compared to the Chinese machines and the advanced country machines. The use of the Kenyan machines in the furniture industry also creates backward linkages with or demand for the informal sector firms fabricating these machines, which also represents an opportunity for employment creation and capacity building in that sector.

However, the story is more complex than this especially considering the fact that the Kenyan machines have the least precision and flexibility of functions. This disadvantage means that using the Kenyan machines will limit the aesthetic quality of the furniture produced in Kenya, which may shift domestic demand away from locally produced furniture to imported furniture and limit the exportability of the furniture manufactured in Kenya. This will also negatively affect the businesses operating in the furniture industry. As noted in Chapter 2, importation of Chinese furniture into Kenya soared recently in response to a shift in domestic demand towards Chinese furniture because of their high aesthetic quality. Thus, a complete reliance on Kenyan machines may not deliver the likely employment creation especially when Kenya is less inclined to adopt industrial protective measures in an era of a global move towards free trade.

While the advanced country machines can produce high quality products in terms of aesthetics, they are expensive and tend to create excess capacity raising production cost. Moreover, the transfer process of the advanced country machines provide limited trading and

distribution linkages in Kenya as the firms which mostly use the advanced country machines tend source them abroad without going through local market traders. For Chinese machines, however, the transfer process involves elaborate sales and distribution networks in Kenya, which represents a source of employment and wealth creation. Moreover, as noted earlier in the summary of findings, the Chinese machines are much less expensive and more labour intensive than the advanced country machines. They also have better precision and flexibility of functions than the Kenyan machines. Hence, using Chinese machines may enhance the aesthetic quality of products compared to Kenyan machines and make the domestic manufacturing firms remain or become more competitive. Their competiveness is critical for employment and wealth creation in Kenya.

The employment creation benefits of the Chinese machines cannot be overemphasised particularly with respect to the youth who have grabbed opportunities in the informal sector to develop and exploit their entrepreneurial abilities. There is an improved access of young artisans or entrepreneurs to automation as a result of the availability of relatively cheap Chinese machines, which offer higher precision and flexibility in terms of functions than the locally fabricated (Kenyan) machines. This can be seen in the fact that Chapter 5 showed that about 42% of the entrepreneurs in the informal sector who were involved in this study were below 35 years of age compared to none for the formal sector firms.

The story about optimality has additional complexities. Over reliance on Chinese machines may also leave domestic capabilities needed for building improved versions of the Kenyan machines underdeveloped. The long-term benefits of developing such capabilities may be substantial for both employment creation and industrial development of Kenya especially if the fabrication is improved to the extent that the precision and flexibility of those machines are comparable to those from China and advanced countries. This will create forward linkages with the wholesale and retail sector in Kenya while delivering the required capital inputs needed for making the furniture manufacturing firms competitive on the local markets and enhancing their export potential. Such potential benefits emphasise the importance of the complementarity between the use of Chinese and Kenyan machines (which was

discussed in Chapter 8), of which some evidence were identified in the empirical data particularly the qualitative data used for this research.

The implications of the findings on employment are similar to those for inequality and poverty reduction. The advent of the Chinese technology has paved the way for poor entrepreneurs to start their own businesses with a relatively high degree of automation they would not be able to afford if the only available technology were the advanced country technology. Thus, the poor entrepreneur is being offered the opportunity to take part in financing economic growth process, job and wealth creation through the availability and use of the Chinese technology. It should be noted that this poverty reduction impact of the Chinese technology also generally characterises the use of Kenyan machines.

The poverty reduction implications together with the employment creation effect highlight the fact that the Chinese and Kenyan machines represent an inclusive innovation. The reason is that they allow relatively poor people access to automation helping them participate meaningfully in economic growth and development while creating employment particularly for the youth, of whom most are not able to find jobs in the corporate and government sectors.

Another important dimension of the findings with regards to inclusion is worth-noting. That is, the formal manufacturing sector of Kenya's economy is dominated by Kenyan Indians while indigenous Kenyans dominate the ownership of businesses in the informal sector, as was evidenced in Chapter 5. Chapter 2 showed that this situation has roots in colonisation in Kenya where Africans in Kenya were barred from agricultural plantation and commerce. The relatively high access of the informal sector firms to automation, made possible by the advent of Chinese and Kenyan technological innovations presents an opportunity for including more indigenous Kenyans in wealth and employment creation in the manufacturing sector.

The findings also point to the fact that the choice of Chinese and Kenyan machines over advanced country machines may produce greater socioeconomic benefits within the informal sector than the formal sector. These categories of firms generally serve demand from different segments of the domestic market. As Chapter 5 showed, while the informal sector

generally serves relatively poor households and the furniture needs of micro and small enterprises, the formal sector firms target rich households, the corporate and public sectors. Thus, the use of the Chinese and Kenyan machines is pro poor or inclusive not only in terms of production but also in terms of producing goods to meet the consumption needs of the poor. It should be noted however that serving the consumption needs of a few consumers who tend to place more emphasis on quality, differentiation and timely delivery of products may require the formal sector firms to rely mostly on advanced country technology even when they are relatively less efficient in the combination of labour and capital in the context of small markets in developing countries.

9.2.2 Policy implications

The forgoing discussions lead to the conclusion that Chinese technological innovations are more amenable for inclusive development and poverty reduction strategies in Kenya than those from advanced countries. The availability of such innovations in China (most likely for many years) may be part of the reasons why, as was indicated in Chapter 1, China has lifted a significant number of her people from poverty while absolute poverty cases for the rest of the world have increased over the last decade. Via increasing trade (specifically, arm's length trade) between China and most other developing countries including Kenya, these inclusive innovations are being increasingly made available to the rest of the world's poor which were hitherto excluded from much of production and consumption. The exclusion can be associated with the predominance of advanced country technologies in developing countries. As Chapters 6 and 7 showed, the advanced country technologies are relatively large scale in nature requiring high sunk cost for investment amid restricted financing options or underdeveloped financial markets, hence, restricting availability and viability to formal production sectors that target high income consumers.

It must be emphasised that the opportunity for the poor and the excluded to participate in the growth process represents an approach which distributes income in a more equitable and justifiable way, compared to other social protection measures which pay little or no attention

to who generates economic growth but seeks to redistribute incomes and improve access to social services through taxation and government transfers. This is especially true in a context like Kenya where corruption, tribalism, and patron-clientele relationship compromise the efficiency of the public service system in delivering public goods and social safety nets for the poor and the excluded. Moreover, social protection via government transfers may only create limited and unsustainable opportunities for upward mobility on the income ladder for the poor since increases in real benefits over time can be rare and it also depends a lot on the government's commitment in the long term. The limitations of the latter approach underpin the importance of the need to support the former, especially in the face of growing inequality and absolute poverty in Kenya, as discussed in Chapter 2.

Support from various actors particularly government that will enhance the penetration and use of the Chinese machines along with the Kenyan machines especially in the informal sector will yield major social and economic benefits for Kenya, and for that matter, developing countries in sub Saharan Africa. Any support should tackle the main problems that inhibit the diffusion of the technologies or prevent the technology or capital goods market in Kenya from functioning properly. This study shows (in Chapter 7) that one of the major reasons why some of the informal sector firms have no investment in machines including the relatively cheaper ones from China and Kenya is the lack of access to finance. Generally, the firms in the informal sector are not able to meet the loan application requirements of the formal financial sector, particularly commercial banks. Loans from microfinance companies which have lower requirements also have high interest cost and limited or no grace period for repayment. The formal sector firms also complain about high interest cost of borrowing from the commercial banks.

Additionally, policy interventions that will support the provision of flexible payment arrangement, where the firms especially those in the informal sector can acquire the technologies on hire purchases can enhance the diffusion of the inclusive technologies.

Another reason why the technology market in Kenya appears to fail is the limited availability of machines parts needed for maintenance and repair. As indicated in Chapter 6, while usable parts of both China and advanced country machines are relatively easy to find on the Kenyan market, their machine parts are difficult to find. Particularly for the informal sector, this problem causes the firms to prefer the Kenyan machines to the Chinese machines. Hence, policy interventions that will lead to an increase in the availability of machine parts for the Chinese technology will enhance its adoption/diffusion.

Another factor that influences the diffusion of the machines especially in the informal sector is related to the limited demand for their products. As Chapter 8 showed, some of informal sector firms find investment in machines economically unviable because of the excess capacity it may create; hence, they depend on others for machining services. For constraints associated with limited market size, Kenyan government's recent directive to public sector offices to channel all public sector procurement of furniture to local manufacturers including those operating in the informal sector is worthwhile and more policy interventions of that nature should be encouraged.

Particularly for the formal sector, other important reasons why the inclusive technologies from China and Kenya are unattractive are the limited durability and robustness of the Chinese machines and the poor functionality of the Kenyan machines. This means that attention should be given to how to enhance the durability, robustness and functionality of the inclusive technological innovations, without significantly compromising their affordability.

Although imperfect market information is one of the major reasons for market failure, it does not appear to be a factor affecting the diffusion of the technologies. Knowledge about the relative availability of Chinese machines and imported items from China on the Kenyan market is extensive. The lower quality or the cheapness of the Chinese machines is also a commonplace.

Finally, it is also important to note that industrial policies for developing countries aimed at reducing unemployment and poverty, and enhancing local technological capabilities should

take into consideration the critical issue of technology choice. Thus, unlike what happened during Kenya's import substitution regime, technology choice should take centre stage of industrial and development policies. The policies should have a focus on technologies that will mainstream the production and consumption needs of those at the lower part of the income pyramid. Given the development objectives, the policies should recognise the various constraints that can affect the social optimality of technology choice such as the lack of well-functioning financial markets, limited local technological capabilities, limited domestic market size, infrastructural deficits, the heterogeneity of firms particularly between the formal and informal sectors as well as the factor endowments of the country concerned.

9.3 Contribution to the literature

The rise of China to economic and global influence has had many socioeconomic implications for the world but particularly for developing countries and especially for sub Saharan African economies. From trade to foreign direct investment and migration to development finance, Chinese presence in these developing countries is much felt to the extent that China has become a major player or an alternative economic cooperation partner for these developing countries. In response, many attempts have been made at studying the effects of China's rise with literature around trade, FDI and migration particularly empirical work becoming abundant.

Nevertheless, not much attention has been given to the impact of the transfer of technologies including capital goods from China to other developing countries in spite of the fact that China's technological capability building has been phenomenal, particularly in the last three decades. Against this background, this research aimed to contribute to filling the gap in the literature, of which the findings significantly attest to the realisation of this aim. It has become obvious from the thesis that Chinese capital goods have different but more desirable impact in terms of inclusive industrial development of SSA economies than the capital goods from advanced countries. Thus, this thesis represents a significant contribution to the literature

given that little was known about the potential impact of Chinese capital goods on SSA economies and developing countries more generally.

Moreover, the findings of the study have important implications for theory especially those that underpinned the conceptual framework, which guided the research. The study has provided empirical evidence supporting the theory of induced technical change. This theory emphasises the importance of market demand in determining the supply of knowledge and technology so that high income markets tend to stimulate the development of technologies that meet the needs of the rich consumers while the reverse is true for low income markets. The technologies from China (and also Kenya) studied in this research are relatively labour intensive and small in scale requiring low capital investment compared to those from advanced countries. This is consistent with the fact that China is a developing country, and by and large, a low-income market, giving rise to the nature of demand that has stimulated the development of such technologies. This implication stresses the idea that technical change can exhibit biases in terms of scale and factor use. This evidence provides a strong justification for the need to give adequate attention to technology choice and it related concept of appropriate technology in the development literature.

Three further implications of the research for technology choice or appropriate technology are also worth mentioning. The first is that the study brings to the fore the need for appropriate technology as a development concept to pay more attention to finance as a constraint to technology choice. Although the literature on appropriate technology emphasise the need for technology choice to be economically appropriate in terms of investment cost and scale, it does not place much emphasis on the role financial markets play. However, the study has shown that the lack of external financing is an important reason why some of the informal sector firms have not invested in automated machines but either rely on hand tools and/or the services of other firms that have invested in automated machines. It is also one of the reasons why the informal sector firms generally do not invest in advanced country machines. Thus, the lack of external financing which is associated with the existence of poor or underdeveloped financial markets can be an important determinant of technology choice.

This is consistent with argument put forward by Hicks (1969) and Bencivenga *et al.* (1995), as noted in Chapter 3.

Second, the analysis of a technology's appropriateness should encapsulate the choice or availability of technology transfer channels, particularly for technologies being transferred from abroad. Among the different transfer channels identified in the literature and represented in the conceptual framework shown in Chapter 3 of this thesis, the most popular mode used for transferring the technologies studied in this research is the arm's length trade. Within the arm's length transfer mode, there are various modes of acquisition, which were identified in Chapter 7. It has been shown that these different modes of acquisition have different development implications, particularly with respect to employment creation as has been discussed under section 9.2 of this chapter. Moreover, although FDI was not identified as a major means of transfer for the technologies studied in this research, the development implications of FDI as a channel of transfer would also be different from the arms' length trade especially since FDI is destined for formal production sectors. Thus, in terms of appropriateness of technology choice, the existence or accessibility of the different channels is also important and the literature should recognise this. It should be noted here that Stewart (1982) mentioned the nature of communication between a country and the rest of the world as a factor that influence technology choice, but this only represents a hint on technology transfer channels. Stewart's analysis also failed to highlight the taxonomy of the transfer channels and their differing implication for technology choice and development.

Third, the appropriateness of a technology for a nation should not be viewed only from a national or macro perspective but more importantly it should be examined in a more disaggregated context. This is implication is derived from the finding that the advanced country technology is economically viable in the formal sector while it was not for the informal sector given the level of actual capacity utilisation. Moreover, the formal sector firms target the high end of the market, whose demand may require them to adopt advanced country technologies instead of the Chinese and Kenyan technologies. Thus, the extent to which the advanced country technology may be inappropriate differs between formal and informal

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sectors firms. This is very crucial especially when the dynamics within the political economy of technology choice is considered. If such disaggregation is absent then the issue about whose interest is paramount gains prominence in technology choice and the politics around it. This is a critical issue for consideration given that the poor are the voiceless and it is harder for them to have their way at the expense of the rich and powerful than 'for a camel to go through the eye of a needle'.

Although less related to the findings on technology choice in this study, another significant aspect of other findings of the study is its contribution to the debate about how to adequately define informality as a feature of a firm. This is a debate that has lingered on for about four decades since Hart (1973) first used the term. Recent studies have indicated that the lack of a generally accepted definition arises because firms that may be collectively described as informal are intrinsically heterogeneous. A significant contribution of this study to this debate lies in the empirical evidence that such heterogeneity can exist even between firms operating in the same industry in such a way that informality should be best described as a continuum. An important implication for any empirical work is that a firm's informality status should be determined on the basis of an extensive list of characteristic indicators, instead of the recourse to a single indicator such as the business registration status of the firm. A more interesting fact is that the analysis in Chapter 5 showed that the Ngong' informal sector cluster appears to be dynamic, persistent, and exhibit relatively high growth potential compared to the other two informal sector clusters. This contradicts the conceptual/theoretical view that represents all informal sector activities as survivalist.

9.4 Reflections and further research

A journey into the unknown is a pure adventure and only the courageous can venture and remain on course. This is how I would describe the whole PhD research process if I were asked to do so. I was very excited when I received my admission letter into this PhD programme especially when the admission came with full funding. With support and guidance from my supervisors, I was able to fine-tune my research questions and protocols

with relative ease. However, what was never clear to me was how to handle operational difficulties during data collection. The key issue was about whether the needed data could be generated to find answers to the research questions and what to do in the event that the data could not be generated. These issues haunted me as I went to do the data collection. Collecting the data took much longer time than expected, as many new strategies different from what were initially thought of had to be developed to overcome various operational challenges, which were discussed in Chapter 4. Moreover, a lot of other data which were not in the initial plan were collected, all in an attempt to avoid leaving out anything important for answering the research questions.

Then, the time for data analysis came. It became obvious I collected more data than I needed. However, deciding on what to leave out was more difficult than the day to day running around in the streets and obscure places of Nairobi and Kisumu for respondents. Many months of mental work and inputs from my supervisors saw me through the analysis stage and finally the writing stage. I feel a little spent but the whole process has helped to put back in me a significant portion of what I lost growing up, that is, a good deal of my inquisitiveness.

Though the PhD research has ended, I look around where I am on my research journey in general and I find more reasons to continue into the unknown. It can be daunting but at the same time it is a lot of fun! Particularly, there are several areas around the subject matter of this thesis that I have identified through this research, which inspire my curiosity. These areas converge around the following questions or issues:

1. How does the influx of Chinese technologies to other developing countries affect the capabilities or potentials of these countries to produce their own technologies (that is, indigenous technological capability building)? In the context of Kenya, the relevant question is about the influence of technology import from China on the capabilities of the local fabricators of Kenyan (jua kali) machines. Relatedly, other important questions are: What is the scope of upgrading opportunities in Kenya's jua kali capital goods sector; and what role are the institutions (such as research institutes,

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universities and technical colleges) in Kenya's national innovation system playing or can play to harness the opportunities?

2. The findings of this thesis show that the informal sector firms may have invested in cheap Chinese technologies while they hope to switch to advanced country technologies as their businesses develop. This suggests a dynamic relationship between the adoption of Chinese technologies and advanced country technologies at the firm level, which could not be fully explored using a cross sectional data collected for this research. It will therefore be interesting to do a follow-up research at a later date, say after five years, to explore this relationship in detail. An opportunity to interview the firms used in this thesis for a second (and probably a third) time will provide data to explore this dynamic relationship.

3. In addition to the dynamic relationship, it will also be interesting to find out if the major findings of this thesis are also true for other subsectors of the manufacturing sector in Kenya and even for broad sectors such as agriculture and industry. Moreover, cross country comparisons for the same sector and across different sectors also arouse a lot of interest.

4. Another area for further research is to find out whether in the context of globally dispersing innovation capabilities, there are also prospects that some technology niches in developing countries particularly Sub Saharan African countries may be filled by other emerging markets such as India, Brazil and South Africa. Further research that studies other sectors of Kenya's economy and even other countries can incorporate this research question.

5. The study found that GVC is not one of the channels by which the technologies studied in this research are transferred to the furniture manufacturing firms in Kenya because the Kenyan firms have weak linkages with foreign furniture manufacturers and markets. Given that participation in GVC has evolved as a means by which domestic firms can maintain their competitiveness, further research should examine

the challenges affecting the firms' involvement in GVCs and come up with strategies to deal with the challenges.

If I am to do the research for answers to the above questions, the lessons from the PhD experience will matter a lot. The major lesson to be learnt from the PhD research is related to the data collection, specifically the samples sizes used for the two round of data collection. The first round, of which the data was mainly used for quantitative analyses including regression, involved interviews with 131 firms. This number was relatively small which limited the number of regressors that could be included the regression models. However, the second round of data collection involved generating qualitative data from the respondents, of which 41 were interviewed. This number was relatively large for the qualitative data that was collected so that the data transcription and data management became very laborious. Consequently, If I were to do everything again, I would probably increase the number of respondents for the first round of interviews to, say, 200 but cut down the number of respondents for the second round of interviews to, say, 25. I would make these changes based on the assumption that the main constraints (such as limited time and funds) on the scope of the PhD research remain unchanged. Moreover, I conducted every single interview myself which was very exhausting. Next time, I will train research assistants to conduct some of the interviews particularly interviews like the first round of the survey.

It is also important to note that the guidance of academic supervisors will be absent from my next research onward. However, the PhD process has also taught me how to be an independent researcher and I am convinced that I can undertake independent research as well as being able to play a meaningful role in any research team.

In the meantime, let me drop my pen for a respite!

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A1: Consent forms for respondents

UNIVERSITY OF NAIROBI
INSTITUTE FOR DEVELOPMENT
STUDIES

Development Policy and Practice Unit

CONSENT FORM FOR PERSONS PARTICIPATING IN A RESEARCH PROJECT
Study title: "Chinese Capital Goods in Kenya's Furniture Industry: An Assessment of Distinctiveness"

Name of participant:

Name of principal investigator(s): Richmond Atta-Ankomah

1. I consent to participate in this project, the details of which have been explained to me, and I have been provided with a written statement in plain language to keep.

2. I understand that my participation will involve being interviewed about my firm, the machines and equipment I use and I agree that the researcher may use the results as described in the plain language statement.

3. I acknowledge that:

    (a) the possible effects of participating in this research have been explained to my satisfaction;

    (b) I have been informed that I am free to withdraw from the project at any time without explanation or prejudice and to withdraw any unprocessed data I have provided;

    (c) the project is for the purpose of research;

    (d) I have been informed that the confidentiality of the information I provide will be safeguarded subject to any legal requirements;

    (e) I have been informed that with my consent the data generated will be stored on The Open University's secured server and will be destroyed after five years;

    (f) if necessary any data from me will be referred to by a pseudonym in any publications arising from the research;

    (g) I have been informed that a summary copy of the research findings will be forwarded to me, should I request this.

    I consent to this interview being audio-taped   □ **yes**   □ **no**
                                                                        (Please tick)

    I wish to receive a copy of the summary project report on research findings   □ **yes**   □ **no**
                                                                        (Please tick)

Participant signature: Date:

Richmond Atta-Ankomah, The Open University, Development Policy and Practice The Open University Milton Keynes, MK7 6AA, UK. Email: Richmond.atta-ankomah@open.ac.uk Tel: +441908858113/+254719445364

A2: Questionnaire for first round of interviews with the furniture making firms

RESEARCH INSTRUMENT

INTRODUCTION
This survey forms part of my PhD research, which broadly aims to assess the various ways in which Chinese technological innovations (embodied in capital goods) used in Kenya's furniture making industry differ from those from developed countries and the implications for poverty reduction and development.

SECTION A: BASIC INFORMATION ABOUT THE FIRM

1   Name of firm   _____

2   Location of firm   _____

3   (a) Nature of furniture manufacturing activity

                [   ] Wood work
                [   ] Metal work
                [   ] Wood and metal work

    (b) Which of the following specific activities is your firm involved in?

                [   ] Furniture making only
                [   ] Machining services only
                [   ] Both furniture making and machining services work

4   Nature of ownership

                [   ] State-owned
                [   ] Publicly listed firm
                [   ] Partnership
                [   ] Family owned
                [   ] Solely owned by an individual

5   Source of ownership   [   ] Foreign

		[ ] Local
		[ ] Foreign and local

6   If foreign owned firm, what is the origin of the owners?

[   ] China
[   ] India
[   ] Other developing countries
[   ] Advanced countries

7   For how many years has your firm been operating   _____

8   If you consider your firm to be a formal sector firm, has it operated in the informal sector before?   _____

9   How many years did your firm operate in the informal sector before moving into the formal sector   _____

10   Is your firm registered?   _____

11   Does your firm belong to any association? Name it.   _____

12   Do you regularly pay taxes to the city council/ government?   _____

13   (a) Does your firm have a bank account or save with a micro finance institution?   _____
(b) How many of such accounts does your firm have?

_____
(c) Have you applied for loan for your business in the last two years?

_____
(d) Have you received any loan for your business from a bank or micro finance institution in the last two years?   _____
(e) How many times in the last two years have you received such loans?

_____
(f) On a scale of 1-7 (where 1 means no access to finance and 7 means very high access to finance), how do you rate your access to finance?   _____

SECTION B: TYPE AND USES OF MACHINES/EQUIPMENT

14   Do you have (light-duty) machines?

15   Which of the following countries do your (light-duty) machines you have come from?

                      (Tick all that applies)

_____

[   ] China
[   ] India
[   ] Kenya
[   ] Other developing countries
[   ] Advanced countries

16   (a) Please, list the major (light-duty) machines and equipment you have that come from these sources

           China   _____
           India   _____
           Kenya (jua kali)   _____
           Other developing countries _____
           Advanced countries   _____

    (b) Please, list the major power tools you have that come from these sources

           China   _____
           India   _____
           Kenya (jua kali)   _____
           Other developing countries _____
           Advanced countries   _____

    (c) Please, list the major hand (manual) tools you have that come from these sources

           China   _____
           India   _____
           Kenya (jua kali)   _____

Other developing countries　　　　　_____

Advanced countries　　　　　_____

17	What percentage of your equipment from the following countries was bought brand new?	Light duty machine	Power tools	Hand tools
	China	_____	_____	_____
	India	_____	_____	_____
	Kenya	_____	_____	_____
	Other developing countries	_____	_____	_____
	Advanced countries	_____	_____	_____

18	To what extent would you say you use equipment from China, India and other developing countries, Kenya and advanced countries for the following activities? **(Use Likert scale)**	**China**	**India &developing countries**	**Kenya**	**Advanced countries**
	• Cutting (sawing/splitting, Planing, chiseling/mortising and drilling)	_____	_____	_____	_____
	• Joinery	_____	_____	_____	_____
	• Sanding/Grinding/filing	_____	_____	_____	_____
	• Patterns and designs	_____	_____	_____	_____
	• Spraying/polishing	_____	_____	_____	_____

19	Generally, what percentage of your production is covered by the equipment from the following sources?	**%**
	China	_____
	India &other developing countries	_____
	Kenya	_____
	Advanced countries	_____

20   When you are purchasing any equipment, to what extent do you consider the following?

     (Use Likert scale)

     Price   _____

     Quality &durability   _____

     Functionality   _____

     Capacity   _____

     Energy consumption   _____

     Type of energy it uses   _____

     Maintenance and repair cost _____

     Skill requirement   _____

21   Why do you purchase Chinese equipment?

_____

22   Do you have any idea about how much you would get if you were to sell all your tools and machines to today?   _____

Questions	China	India & other dev. countries	Kenya	Advanced countries
23 To what extent will you say you get informed about the equipment before purchasing by the following ways: **(Use Likert scale)**				
• Advertisement	_____	_____	_____	_____
• Parent company	_____	_____	_____	_____
• Major customers (Lead firms)	_____	_____	_____	_____
• Equipment suppliers	_____	_____	_____	_____
• Employees	_____	_____	_____	_____

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- Other input suppliers   _____ _____   _____ _____
- A competitor firm   _____ _____   _____ _____
- Firms that give you subcontracts   _____ _____   _____ _____
- Firms we give subcontracts to   _____ _____   _____ _____
- Friends &family   _____ _____   _____ _____

24   (a) How do you get your equipment?
          (Tick all that applies)
- Purchased from a market dealer   _____ _____   _____ _____
- A joint venture partner provides them   _____ _____   _____ _____
- Parent company of the firm provide them _____ _____   _____ _____
- Another firm purchased them   _____ _____   _____ _____
- Others (specify) _____   _____ _____   _____ _____

(b) If another firm purchased the machine, what kind of
relationship exists between your firm and that firm?   _____

SECTION C: LABOUR SUPPLY AND WORKFORCE

25   Number of employees   Full time_____
                                  Part time/casuals_____

26   What is (do you have any idea about) the average age of
     your workforce   _____

27   What is the average schooling years of your workforce   _____

28   How many (what percentage) of your workers have
     received training from the following sources?
- University   _____
- Polytechnic   _____
- High school   _____
- Apprenticeship   _____

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29   Are your workers registered with the social security office
or are they on any pension scheme?   _____

30   Do your social security registered workers include
casual/part time workers?   _____

SECTION D: SUBCONTRACTING (FINAL PRODUCTS)

Questions	Subcontract you receive	Subcontracts you give
31 How often do you do subcontracts?		
• No subcontracts	_____	_____
• Not often	_____	_____
• Often	_____	_____
• Very often	_____	_____
32 How many (or what percentage) of the firms you do subcontracts with would say are micro and small enterprises?	_____	_____
33 What percentage of all the firms that you do subcontract with are foreign firms	_____	_____
34 What percentage of the local firms you do subcontract with would say operate in the informal sector?	_____	_____
35 What percentage of your output/sales per annum involves subcontracting?	_____	_____

SECTION E: PRODUCTS, MARKET AND CUSTOMERS

QUESTIONS	Final Products	Components
36 a. Which of the following categories of products do you produce? **(Tick all**		

that applies)

- Office   _____   _____
- Domestic

b. If you produce both office and domestic artefacts, what share of the products you manufacture constitute office artefacts?   _____   _____

c. Please, list the major variety of office artefacts you produce.   _____   _____

d. Please, list the major variety of domestic artefacts you produce.   _____   _____

37   What percentage of your total production constitutes components making?   _____

38   Which of the following categories of consumers constitute the main target market of your firm? **(Tick all that applies)**

- High income consumers   _____   ___N/A____
- Middle income consumers   _____   ___N/A____
- Low income consumers   _____   ___N/A____
- Other firms   _____   _____

39   If other firms purchase your products, how many of the firms would you say are medium and large scale firms   _____   _____

40   Which of the following is the major market for your firm? Foreign, domestic or both?   _____   _____

41   What proportion of the local firms that buy your products operate in the formal sector?   _____   _____

42   To what extent do you think your customers consider the following when purchasing from you?
        (Use Likert scale)

- Price   _____   _____
- Prompt delivery   _____   _____
- Quality & durability   _____   _____
- Design & aesthetics   _____   _____

- Opportunities for repair/maintenance   _____   _____
- Warrantee /guarantee   _____   _____

SECTION F: ABOUT THE ENTREPRENEUR/MANAGER

43   Sex   _____

44   Age in completed years   _____

45   Number of years of formal schooling   _____

46   Level of education   [   ] Basic or primary
[   ] High school
[   ] Polytechnic
[   ] University

47   Do you have a business card?   _____

48   a. Did you work in the informal sector any time before starting your
current business?   _____

b. For how many years did you do such work?   _____

c. What was the area of your previous business/employment in the
informal sector?   _____

d. Did you own that business?   _____

e. Why did you stop doing this work?   _____

f. Would you like to go back and work in the informal sector?   _____

49   a. Did you work in the formal sector any time before starting your
current business?   _____

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b. For how many years did you do such work? _____

c. What was the area of your previous business/employment in the formal sector? _____

d. Did you own that business? _____

e. Why did you stop doing this work? _____

f. Would you like to be employed again in the formal sector? _____

50   What is your view of Chinese presence in Kenya? _____

51   In what ways do you think Chinese presence in Kenya is helping you in your business? _____

52   What is your view of Chinese equipment? _____

53   Would you be interested in being part of this research further? _____

Thank you for your time!

A3: Questions for second round of interviews with the furniture making firms

Questions	Machine 1	Machine 2	Machine 3
1 Basic information about machine:			
(a) Type of machine (Planing, bandsaw, saw bench or lathe)			
(b) In what year did you purchase the machine?			
(c) From which country does the machine come from?			
(d) Was it new when you purchased it?			

(e) How much did it cost to purchase the machine?

(f) How much does it sell now on the market

(g) Why did you buy the machine from this source?

2   Scale:

)a) Size of machine (width of thicknesser planer, size of tilting table for band saw, length

of lathe, size of working table for saw bench)

(b) What is the horse power of the machine?

(c) How many electrical phases does the machine have?

3   The run of the machines:

(a) How long do you expect to use your machine?

(b) How many hours is the machine designed to work?

4   Breakdown, motor rewinding and overhauling:

(a) How often do you get breakdowns within a year?

(b) Have you rewound the motor?

(c) How long did you use the motor before your rewinding?

(d) How many times have you rewound the motor?

(e) How much did it cost to rewind each time?

(f) Have you ever replaced the motor?

(g) Why did you replace it?

(h) How many months did you use the old motor before you replaced it?

(i) Horse power of new motor?

(j) How many phases does the new motor have?

(k) Is the "new" motor second hand or brand-new?

(l) How much did you buy the new motor?

(m) From which country does the new motor come from?

(n) How many times have you replaced the motor?

(o) Do you think the new motor is better than the old?

(p) Is there any other thing you have changed on the planing machine? (e.g. Rollers, capacitors, cutterblock, bushes etc.)

(q) How many hours is this machine able to work after changing the motor?

5   Is it easy to find repairers? On average, how much do you spend to repair this machine?

6   (a) Output when motor had not been changed?

    (b) Output after changing motor/overhauling?

7   How ease is it to operate this machine?

8   Are there any safety problems associated with using this machine?

9   Are you happy with the quality of output of the machine? How does it compare with other machines?

10   Transfer/ purchasing process and financing

    (a) From where or how did you buy the machine?

    (b) Did you get guarantee?

    (c) Did they provide any after sales service?

(d) How do you raise money to buy the machines? Do you use bank/microfinance loans?

(e) Apart from getting the machine from the supplier, do you have any other business relationship with the suppliers? Could you describe this relationship? Does this relationship help you any way in getting the equipment?

11 How many people normally operate this machine? How are they paid? How much do you pay them?

12 How easy is it to get both machine and usable parts for this machine?

13 How do you get electricity supply? On average, how much do you spend per month on electricity?

14 How much do you spend per month on rent?

15 (a) If you do machining services work, how much revenue are you able to make in month on machine services?

(b) What percentage does this constitute out of all your monthly revenue

16 What challenges are you facing in your business?

A4: Questions for interviews with firms trading/supplying the machines

No.	Questions
1	Name of the firms
2	Location/address of the firms
3	For how long has this business been in operation?
4	How many people work for you?
5	How many outlets do you operate in Kenya?
6	Please, describe the spread of your outlets across the country?
7	Is your firm a subsidiary of larger international firms? In which country is the head company based? **Who** are the owners of the firm?
8	To what extent does your firm deal in metal and wood working equipment or machines? **(Ask for a rough proportion)**
9	For how long have been selling Chinese equipment?
10	To what extent does your company deal in Chinese metal and wood working equipment as compared to those from advanced countries? **(Ask for a rough proportion of the wares)**
11	Apart from the Chinese equipment, do you also deal in equipment from other countries including advanced countries?
12	Compared to equipment from advanced countries, to what extent would you say that Chinese equipment has better demand than those from advanced countries?
13	Do you sell Chinese equipment (particularly metal and wood working equipment) in all your outlets?
14	Do you provide after sales services to your customers? Please, can you describe them?
15	How much guarantee (if any) are you able to provide on Chinese equipment? How does this compare with advance countries' equipment?
16	How do you get your supplies?
17	Under what conditions do you get your supplies? What kind of agreement exits between you and your suppliers?
18	Is your firm a subsidiary of the supplier? What kind of business relationship exists between you and your supplier?
19	Is your supplier the manufacturer of the equipment? Do you have any idea about how your supplier obtained the equipment?
20	Generally, to what extent do you advertise Chinese equipment compared to those from advanced countries?
21	What problems do you encounter in purchasing your supplies locally or abroad?

22   Is there anything the government is doing to help you deal with these problems?

23   To what extent will you say that selling Chinese equipment brings more profit than those from advanced countries?

24   Would say that selling Chinese equipment has enhanced your business? Has it helped you to employ more people?