Industrial Competitiveness and Firm Dynamics in Sub-Saharan Africa

A Firm-Level Analysis with a Focus on Ethiopian Manufacturing

A thesis submitted by
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1 Introduction

For African economies, increasing the contribution of manufacturing to gross domestic product (GDP) and exports remains a critical development challenge. On both accounts Africa has not only lagged behind other developing regions, it has even fallen below its own recent performance levels. Unfortunately, the waves of economic reform measures introduced since the mid-1980s have not brought about the expected turnaround; in fact they are often blamed for being part of the problem(Noorbakhsh and Paloni 1998, Lall and Wangwe 1998). The small size of domestic markets and poor infrastructure linking them have long been identified as major structural problems that dictate small firm size and diseconomies of scale in African manufacturing. Recent explanations have tended to emphasise the volatility of the macroeconomic and political environment, and the prevalence of corruption in Africa, which are said to render the region's investment climate too risky for both the domestic and foreign private sector. The underlying assumption in these explanations is that firms respond in an identical fashion to country/industry-wide incentives and shocks. While such macro-level explanations provide valuable insights, little is known about the firm-level performance and dynamics of manufacturing industries, in the developing world in general and even less so in sub-Saharan Africa. This of course started to change after the mid-1990s, with gradual improvements in the availability of micro-data, which among other things revealed a remarkable heterogeneity of firms (in terms of market share, efficiency, profitability, growth, etc.) within a narrowly defined industry and within a given macroeconomic and institutional framework. This has inspired and permitted a new research direction which closely examines variation in firm-level responses within a certain macroeconomic and institutional framework and their implications for aggregate outcomes. Tybout (2000) and Bartelsman and Domes (2000) reviewed this literature, respectively, for developing and developed countries.

Accordingly, the current study investigates the firm-level dynamics that underlie the aggregate performance of African manufacturing. Its aim is to explain the competitiveness of African manufacturing industries based on three interrelated micro-processes: (i) market selection of efficient producers, (ii) accumulation of technological capabilities and (iii) accumulation of physical capital. Key aspects of the competitiveness debate at the macro level, which is how it all started, are highlighted below followed by a more process-oriented micro-level working definition of competitiveness in line with the three abovementioned elements.

Concerns about competitiveness originated in developed countries, which felt a keen urge to maintain their industrial and technological leadership against what they perceived as a growing challenge from developing countries. At the same time, trade liberalisation and technological advances in transport and communication increased the degree of competition developing countries faced, rendering competitiveness a critical development issue. Although competitiveness is now a widely used concept in policy circles and academia, a lack of clarity remains about its meaning and determinants. While the concept can be applied at the firm, sector and country levels, competitiveness nonetheless has often been used in the context of cross-country relative performance. In this regard, competitiveness is widely defined as the ability of a country to produce goods and services that meet the test of international competition while its citizens enjoy a standard of living that is both rising and sustainable (OECD 1992). This definition combines performance in international trade with growth in per capita income, and its underlying dynamics go beyond static efficiency, which is the hallmark of the competitiveness issue. For neoclassically oriented economists, the competitiveness debate has been described as not only misguided but also ‘a dangerous obsession’ that may lead to protectionism (Krugman 1994). For them, the foregoing definition is unhelpful, simply because there is no direct link between export performance and growth in per capita income except for the one-off welfare gain due to specialisation in commodities that intensively use a country’s abundant resources. Corden (1994), for instance, argued that the competitiveness challenge is a matter of striking a judicious balance between the tradable and non-tradable sectors of an economy, which can be achieved through adjustment of the real exchange rate and real wages. In this view countries could also boost their long-term competitiveness through productivity growth that is driven by exogenous technical change. However, a country could remain competitive even when productivity is declining if it can reduce real wages (Corden 1994). This analysis is obviously based on the representative firm approach and relies heavily on unit labour costs for competitiveness, ignoring the role of non-price factors. Nonetheless, the wide diversity of firm-level performance and response within a narrowly defined industry means that the representative firm approach is inadequate for understanding true industry dynamics (Nelson 1981). Ignoring the importance of non-price factors, moreover, severely limits the scope of the analysis and the policy options for competitiveness. Although it started in policy circles, at the macro level the competitiveness debate has gained theoretical support, with non-price factors, particularly technology, starting to appear directly in the new growth models.[1]

Unlike the OECD’s (1992) definition of competitiveness, which relies on final outcomes in terms of export success and growth in real wages, the current study views competitiveness as a dynamic process with some desirable attributes. Specifically, it refers to industrial progress that is driven by the processes of market selection, accumulation of technological capabilities and investment. The basic argument behind this working definition is as follows: To begin with, the allocation of market shares as well as the entry and exit of producers in an industry should be dictated by market forces if an industry is to be reckoned as competitive. This requires tolerance of inefficient producers and entry barriers kept to a minimum. In this framework, however, the focus is on market selection and the associated reallocation of resources toward more efficient producers of existing products and as such not on industry dynamics associated with the introduction of new and better products and processes. Historically though, industrial success has been underpinned by the introduction of new and better products (Kuznets 1971, Stokey 1991). Competitiveness, therefore, involves industrial progress due not only to efficient allocation of resources but also to innovation. This dimension of competitiveness is receiving growing attention as global production and export of manufactures are increasingly driven by demand for medium- and high-technology commodities. Finally, competitiveness requires expansion of production capacity through investment by efficient and innovative firms. The current study thus examines firm-level capital adjustment patterns and their effect on industrial competitiveness in a region known for multiple sources of uncertainty and high adjustment costs.

This research therefore focuses on the micro-processes of market selection, technological capability accumulation and investment as determinants of competitiveness. It utilises insights from three strands of literature that explicitly recognise firm heterogeneity to better understand the dynamic nature of competitiveness. These are (i) dynamic models of industrial evolution (also referred to as models of market selection), (ii) the technological capabilities approach and (iii) theories of investment under uncertainty and non-convex adjustment costs. These three approaches have strong micro-foundations and serve as organising frameworks for an emerging body of empirical literature on industrial evolution, which is conspicuously scarce for sub-Saharan Africa. While these approaches eschew the representative firm approach and share a number of common grounds, their emphases are quite different. Theories of industrial evolution focus on the proper functioning of markets and their ability to select inherently efficient firms as a source of aggregate productivity growth. Although certain versions of market selection models incorporate selection under innovation and active learning, the focus still remains on the market mechanism. It is important to note that models of market selection are closely related to models of investment, as they assume survival and growth of efficient firms. The technological capabilities approach, on the other hand, stresses the importance of firm-specific capabilities as determinants of long-term competitiveness. This approach looks at technological learning in the context of developing countries, where there are significant markets failures. Modern theories of investment look into the role of uncertainty in investment where investment is hard to reverse and adjustment costs are non-convex. Competitiveness could suffer in this case if uncertainty and adjustment costs reduce the smooth adjustment of capital stock to desired levels.

This thesis is based on four articles which investigate these three dimensions of competitiveness in detail. The articles, appearing as chapters 3 to 6, employ the abovementioned analytical frameworks to analyse the three dimensions of industrial competitiveness independently. The thesis looks at the individual contributions without endeavouring to provide a single behavioural model that embodies selection, innovation and investment. While a comprehensive theoretical model that satisfactorily addresses the three dimensions is also lacking in the literature, this does not prevent us from analysing their respective roles in industrial competitiveness using the existing frameworks highlighted above. The final chapter, however, provides a synthesis of the lessons drawn and the interdependence among them. It is recognised that the micro-processes investigated are interdependent and that industrial competitiveness would require the joint operation of the three dimensions. For instance, firms would have no incentive to innovate if markets did not exert competitive pressure. Competition may, however, fail to provide a sufficient condition for innovation due to market failures surrounding technological learning. Competitiveness may also suffer if innovative firms fail to take advantage of their competitive edge through investment.

The firm-level analysis of industrial competitiveness in this study has an interesting parallel with a cross-country analysis based on disaggregated exports. In what promises to be a resuscitation of the industrialisation agenda, a new crop of empirical research shows that the path to development is marked by building capabilities for a broader range of products, as opposed to specialisation in endowment-based comparative advantage, and that different sectors offer differing potentials for diversification and hence growth. Imbs and Wacziarg (2003) showed that countries go through a long process of diversification before they start to specialise in a relatively narrow range of products for export; and the tipping point occurs relatively late in the development process. Hausmann, Hwang and Rodrik (2005) showed the importance of the "quality" of a country's export basket in determining its future growth rate, which is consistent with Klinger and Lederman (2004) who point out the importance of discovery of new products (defined in terms of new export items for a country and not necessarily for the world). However, new products require new and product-specific capabilities which are rife with market failures. In the words of Hausmann and Rodrik (2006: 37), 'Unless purposeful action is taken to move towards new activities, countries may not be able to overcome the market failures that affect the process of structural transformation. Seen in this perspective, industrial policy is a central part of any development strategy.' While the stylised facts from these studies clear much of the cloud surrounding the role of industrialisation, discovery and diversification for growth in developing countries, the difficult task of industrial policymaking ultimately requires more firm-level information and analysis to be effective. For instance, which firms are most likely to introduce a new product? Which ones have the greater chance of surviving and investing? What sort of capabilities do firms require to grow and gain efficiency? By addressing these and other similar questions, this thesis contributes to the industrialisation debate in the context of sub-Saharan Africa.

The organisation of the thesis and its contributions to the relevant literature are as follows. Chapter 2 provides background information that describes key aspects of Ethiopian manufacturing, recent developments in the political economy of the country and the data used in subsequent chapters.

Chapter 3 deals with market selection and its contribution to industrial competitiveness. It uses transition matrices and a decomposition of aggregate productivity growth to assess how effective African markets are in selecting efficient firms and how much selection contributes to aggregate efficiency. The analyses in Chapter 3 constitute the first attempt, as far as the author is aware, to estimate producer turnover and reallocation of market shares and their respective roles in aggregate productivity in the context of sub-Saharan Africa. The results of the analyses are therefore much more readily comparable with the empirical literature on market selection for mature market economies.

The life cycle of firms in terms of entry, survival and growth is addressed in Chapter 4. This chapter uses duration models and growth regression to delve into the determinants of firm survival and growth, the results of which constitute econometric tests of market selection. The survival analysis in this chapter adds to the limited number of survey-based studies linking survival of African firms with efficiency (Frazer 2005, Soderbom et al. 2006). It does so by providing first hazard estimates derived from duration models applied to census-based panel data that excludes micro-enterprises.

Chapter 5 investigates the nature and role of technological capabilities for industrial competitiveness. The empirical strategy in this chapter is to describe the distribution of several indicators of technological capabilities and employ econometric techniques to relate them to firm-level performance in terms of productivity and firm growth. Apart from collecting and analysing primary data on the technological capabilities of Ethiopian manufacturing firms, an innovative aspect of this chapter is the effort to link two data sources – a census of manufacturing firms and the author's survey – to answer questions related to innovation, productivity and growth.

Chapter 6 investigates capital adjustment patterns in African manufacturing vis-à-vis advanced countries. It also examines the role of uncertainty and other determinants of investment and their relationship with productivity and innovation using a combination of parametric and non-parametric techniques. This chapter contributes to our understanding of the investment behaviour of African manufacturing firms by looking at disaggregated investment within a firm and addressing some methodological aspects of analysing the effect of uncertainty on investment.

Chapter 7 synthesises the roles of markets, innovation and investment based on the empirical findings of the preceding chapters and draws some implications for industrial policy.

Notes to Chapter 1

1. Researchers also test this hypothesis empirically by linking export and export-related performance indictors to price and non-price factors, as in Fagerberg (1996).

2 Background

2.1 The Political Economy of Ethiopia

Modern manufacturing in Ethiopia does not represent a natural progression from the country's ancient civilization and cottage industries. Rather, its foundations lie in the emergence in the early 20th century of a strong central government and major cities along the now tattered Ethio-Djibouti railway. Fuelled by foreign direct investment, manufacturing started to play an important role in the domestic economy after World War II. By 1974, foreign nationals had full or majority ownership of 143 enterprises (52%). The then imperial government facilitated this process through its five-year development plans, which offered generous incentives to foreign investors.

The ownership structure and organisation of the business sector changed radically after the military regime came to power in 1974. All medium- and large-scale manufacturing enterprises that were in the hands of local and foreign private owners were nationalised, along with banks, insurance companies and large commercial farms. The management of manufacturing enterprises was highly centralised under a few corporations, which took decisions on how much to produce and at what price. The government established its own manufacturing enterprises as well, and controlled the factor markets in such a way that public enterprises would enjoy preferential access to credit, foreign exchange and skilled labour. As in the previous regime, import substitution continued to be the main industrialisation strategy, but this time with high tariff and non-tariff barriers.

With the coming to power of a reformist government in 1991, the country began to implement World Bank/IMF-type structural adjustment programs. The reform measures encompassed macroeconomic stabilisation and trade liberalisation as well as some elements of industrial policy reform. Trade policy reforms included the reduction of import tariffs and elimination or reduction of export taxes, non-tariff barriers and import licensing requirements, as well as the introduction of export promotion schemes. Tariffs were substantially slashed; the maximum tariff was reduced from 240% in 1991/92 to 40%. The weighted average tariff now stands at 19%, and it is expected to decline further since the country adheres to the regional trade agreement of the Common Market for Eastern and Southern Africa (COMESA).

A number of reform measures best described as part of the country's industrial policy were also put in place. Most of these are contained in the country's Investment Law, which was first issued in 1992 with subsequent revisions and improvements. These policies aim at enhancing private-sector participation (i) by allowing entry into economic activities formerly reserved for the state sector, (ii) by removing caps on private investment and (iii) by providing a range of incentives to enterprises including tax holidays. The Public Enterprises Reform Act of 1992 was a key industrial policy reform aiming to place public enterprises on a level playing field with their private-sector counterparts by divesting public entities of their preferential access to factor inputs and by granting them managerial autonomy.

At the macro level, the government committed itself to fiscal and monetary discipline in an effort that so far has been judged credible by the Bretton Woods institutions. The country's macroeconomic development has been marked by low inflation and manageable fiscal and current account deficits (discussed further in Chapter 6 and depicted in figure 6.1). Another key feature of the macroeconomic environment is the exchange rate regime, which has been made increasingly market driven. Other important measures in connection with private-sector development include a new labour law which gives employers more flexibility in managing their labour inputs and a reduction in the time and effort needed to clear imported goods from customs and get investment licenses. There has also been a concerted effort to upgrade the country's physical infrastructure, particularly roads and telecommunications, with tangible improvements made despite the long way yet to go to bring these and other infrastructure services to satisfactory levels.

These encouraging developments have, nonetheless, at times been overshadowed by uneasy developments in the political economy of Ethiopia. Following the removal of restrictions in the early 1990s, private investment started to pick up pace backed by an accommodating credit flow from the banking sector. In the mid-1990s, however, a number of businesses mainly in the services sector began to experience difficulties in repaying their loans. Tension increased as the non-performing loans of the state-owned and largest commercial bank (the Commercial Bank of Ethiopia) mounted. Subsequently, the Bank Foreclosure Law was enacted in 1997 allowing banks to sell the mortgaged assets of defaulting firms without having to first go to court. The provision to bypass the legal system may seem pragmatic given the weaknesses of the latter to handle such cases in a timely and orderly manner. However, private businesses perceived the law as tough and unfair, as it bestowed excessive power on one partner (the banks) of a financial contract. Investors therefore become very cautious about borrowing, which manifested in a steady decline of private-sector borrowing from 1997 onwards (see also Chapter 6, figure 6.2).

Following the border conflict with Eritrea in the late 1990s, a serious political crisis again arose in 2001 as the Tigray People Liberation Front (TPLF), the leading partner in the coalition-based ruling party Ethiopian People's Revolutionary Democratic Front (EPRDF), split into two. This apparently internal party affair had national repercussions, starting with the decree of the Anti-Corruption Law in 2001, which introduced yet another shock to the business sector. The dissenting voices from within the party, and key figures in the financial and business sectors who were said to be connected to them were jailed on the basis of the law a few days after its enactment. For international organisations and donors, including the World Bank and IMF, this move signalled a strong state committed to good governance and fighting corruption. Political analysts and the local private media, however, interpreted it as a sign of an authoritarian regime determined to stamp out any opposition and the corruption charges as simply safe and suitable pretexts. While the reality may lie somewhere in the middle, the incident undoubtedly sent a negative signal to the business sector, further dampening the keenness of the already reticent banks and businesses to engage in investment-related financial transactions. It is interesting to note that since 2001, the excess reserve of commercial banks has risen to unprecedented levels while net lending to the private sector has slipped into negative territory (see IMF 2006 and figure 6.2 for details).

In a number of other instances too, expectations of the business sector and the actions of the policymaking apparatus seem out of sync in Ethiopia. The introduction of the value added tax (VAT) in 2003 to replace the sales tax, for instance, was seriously challenged by the business community as “untimely” based on the country’s inadequate information infrastructure and the unequal treatment of firms that it entails. Even more serious was the debate between government and the business community about the introduction of a tax foreclosure law, which would allow the tax authorities to sell business properties, again without need for prior court approval, if businesses failed to pay their taxes. The private sector, through its chamber of commerce, argued that the time allowed for compliance (30 days) was too short given the weak performance of the economy and also in comparison with practices elsewhere. The debate, which was the major headline at the time of the fieldwork for this research (January to April 2004), ended with the outspoken leaders of the business community (the president and secretary-general of the Addis Ababa Chamber of Commerce) fleeing the country, presumably for fear of detention. Ironically, this showdown took place at a time when the country was hosting a key international trade fair organised by the Addis Ababa Chamber of Commerce. Reading the local news, a foreign investor from the Netherlands participating in the trade fair commented, ‘What are the authorities trying to tell us? Don’t come here?’ It is against this background – that of a nation with liberalised and fairly stable macroeconomic conditions and yet a tense relationship between the public and private sector – that this research examines the firm-level dynamics of Ethiopian manufacturing.[1]

2.2 Basic features of Ethiopian manufacturing

Ethiopian manufacturing exhibits several commonalities with the manufacturing sectors of other sub-Saharan African economies. The country's ratio of manufacturing value-added to GDP, which in the 1960s was about 14%, fell and has stagnated at about 8% since the 1980s — slightly below the sub-Saharan African average of about 11%. Table 2.1 provides basic information about the state of manufacturing in Ethiopia during 1996–2002. The industrial structure of the manufacturing sector reflects the dominance of low-technology industries oriented toward the production of consumer goods. For instance, the food and beverage and textile and garment industries together accounted for about half of total output and 60% of manufacturing employment. There was a sharp decline in the proportion of public enterprises during the study period, partly due to the process of privatisation but mainly due to the entry of new private enterprises. The reduction in public enterprises was marked, with the state sector accounting for just 58% manufacturing employment in 2002, down from 85% in 1996. In terms of manufacturing value-added, the share of public enterprises also fell, from 78% in 1996 to 62% in 2002.

Ethiopian manufacturing expanded during 1996–2002. Figure 2.1 shows that manufacturing output and value-added grew on average by 5.2% and 6.6%, respectively.[2] After 2000, however, growth slowed, with an absolute decline in 2002. Although foreign capital was crucial at the inception of Ethiopia's modern manufacturing, at the moment less than 5% of firms have non-zero foreign capital. There is, however, a positive trend in foreign direct investment particularly in

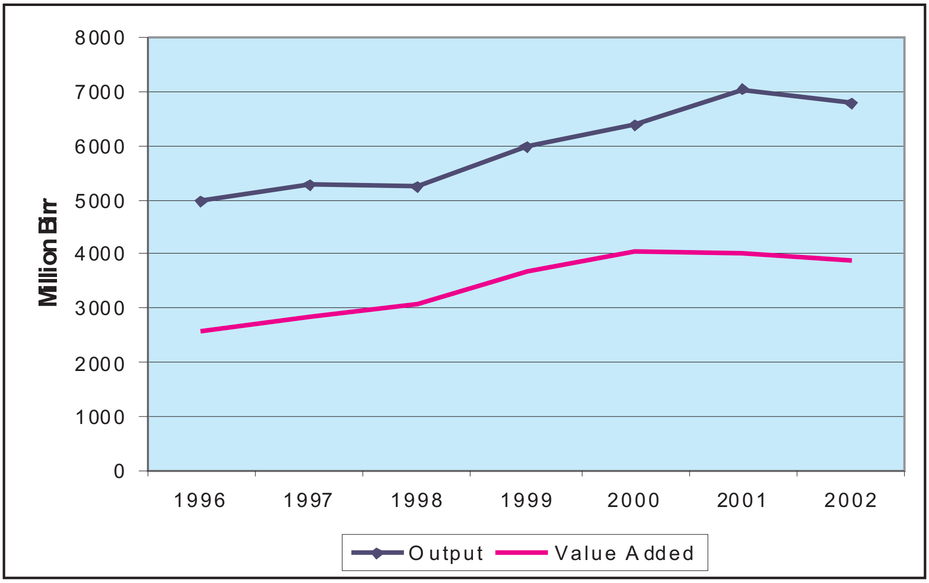


Figure 2.1: Trends in total manufacturing output and value-added (constant 1996 prices)
Source: Author's computations based on CSA data.

industries with high import competition (measured in terms of import penetration rate) such as textile and garments, chemical and plastics and light machinery. Except the food and beverages industry, which has a four-firm concentration index of about 40%, other industries exhibit low levels of market concentration suggesting a competitive market condition.

Figure 2.2 shows the size distribution of firms in terms of employment. The right skew points to the dominance of small firms in Ethiopian manufacturing. There has also been an increase in the dominance of small enterprises shifting the size distribution slightly to the left between 1996 and 2002. The main reason for this is the high rate of entry by small firms, although downsizing of large firms has also played a role. It is interesting to note that the size distribution of Ethiopian manufacturing firms does not show the "missing middle" observed in many developing countries (Tybout 2000). This refers to a bimodal size distribution dominated by small firms at the lower tail of the distribution and by another (smaller) hump of large firms at the upper tail with a trough in the middle due to a low frequency of medium-sized enterprises. Apparently this is not the case in Ethiopian manufacturing. Table 2.2 presents the size distribution by industry, showing the growing dominance of small firms in some industries, particularly those in the food and beverage and wood and furniture categories. The last row of the table shows an increase in the share of medium-sized firms in 2002 compared to 1996 while the fraction of large firms declined.

According to table 2.3 the level of education of entrepreneurs in Ethiopian manufacturing is lower than that in Nigeria, comparable to that in Kenya and relatively better than that in Uganda and Mozambique. Looking at the educational

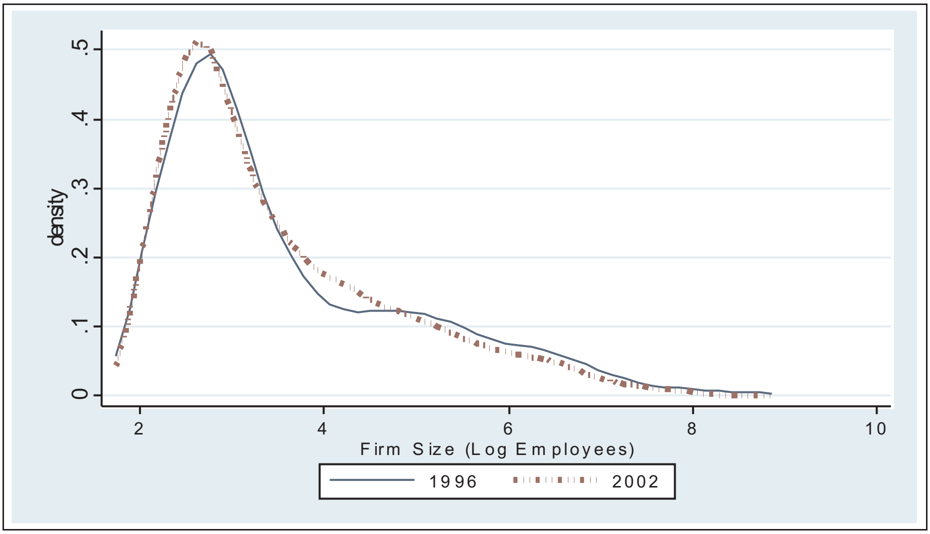


Figure 2.2: Size distribution of Ethiopian manufacturing firms

Source: Author's computations based on CSA manufacturing census.

Note: The kernel is Epanechnikov.

Table 2.1: Basic features of Ethiopian manufacturing

	Industrial Composition of Manufacturing (%)*			Four-Firm Concentration Ratio (%)*	Capital per Worker (000 Birr)*	Import Penetration Ratio (%)*	Public Enterprises (%)		Enterprises with Foreign Capital (%)	
	Output	No. of Firms	Employment	1996–2002	1996–2002	1996–2002	1996	2002	1996	2002
1	2	3	4	5	6	7	8	9	10	11
Food and Beverage	40.3	27.6	24.9	40.3	52.9	14.0	31.8	14.5	0.0	3.2
Textile and Garments	12.0	9.1	35.9	12.0	32.2	48.8	50.0	34.3	4.8	7.5
Chemical and Plastic	11.9	9.5	7.7	11.9	81.9	69.0	27.5	19.0	0.0	8.9
Metal	10.6	7.3	3.6	10.6	50.9	61.1	15.6	10.6	11.1	9.1
Leather and Footwear	9.3	7.7	8.2	9.3	86.5	30.8	14.8	13.7	6.6	9.8
Non-metal	7.1	9.9	5.9	7.1	32.6	21.2	24.6	23.0	4.3	1.4
Printing and Paper	5.2	7.9	6.3	5.2	30.1	48.7	21.4	12.5	4.8	2.8
Wood and Furniture	2.4	17.8	5.9	2.4	16.0	54.2	17.8	7.4	5.0	3.4
Light Machinery	1.2	3.1	1.5	1.2	52.3	98.3	13.6	17.7	9.1	23.5

Source: Author's computations based on CSA's manufacturing census. *Average for 1996–2002.

Note: The table excludes the tobacco industry, since one public enterprise has a monopoly. Industries are sorted by share in total manufacturing output, i.e., column 2.

Table 2.2: Size distribution of firms by industry (percent)

	1996			2002		
	Small	**Medium**	**Large**	**Small**	**Medium**	**Large**
Food & Beverage	57.0	15.2	27.8	63.7	15.7	20.6
Textile & Garments	40.3	14.5	45.2	31.3	25.4	43.3
Leather & Footwear	62.3	14.8	23.0	41.2	33.3	25.5
Wood & Furniture	66.3	23.8	9.9	78.4	14.2	7.4
Printing & Paper	52.4	28.6	19.1	56.9	31.9	11.1
Chemical & Plastic	56.9	15.7	27.5	40.5	34.2	25.3
Non-metal	71.0	13.0	15.9	70.3	16.2	13.5
Metal	71.1	13.3	15.6	62.1	24.2	13.6
Machinery	77.3	9.1	13.6	64.7	23.5	11.8
Total	60.3	16.9	22.8	59.9	21.4	18.7

Source: Author's computations based on CSA manufacturing census.
Note: Small = 10–29 employees, medium = 30–99, large = 100 + . Numbers add up to 100 row-wise.

achievement of general mangers, including both private and public enterprises, the Ethiopian situation is comparable to that of Nigeria but still lower than that in China and in India, where nearly all entrepreneurs have a university education.[3] The level of formal education of firm owners and managers in Ethiopia, therefore, seems relatively better than in other countries in sub-Saharan Africa. Compared to Kenya and Uganda, where nationals of Asian origin run most of the manufacturing firms, about 90% of business owners in Ethiopia are originally from Ethiopia.

The table also shows that the average years of experience of Ethiopian entrepreneurs before opening a business is similar to that in Kenya and Uganda. There is a big difference, however, in terms of experience gained by working for a foreign firm. In Ethiopia only 13% of owners have such experience, whereas that proportion is nearly double in Kenya and Uganda. This is unsurprising given the current ethnic composition of the Ethiopia's entrepreneurs, who are predominantly Ethiopian by origin.

In conclusion, Ethiopian manufacturing is at an early stage of development, as reflected in the dominance of industries producing light consumer goods. The sector has little or no export orientation, and small private firms play a key role. The firm-level dynamics investigated in subsequent chapters should be evaluated in this light.

2.3 The data

This study draws upon two data sources: a census of Ethiopian manufacturing firms conducted by the Central Statistics Authority (CSA) of Ethiopia during the period 1996–2002 and a sample survey of 127 Ethiopian manufacturing firms conducted by the author from January to April 2004.

Table 2.3: Educational levels of manufacturing entrepreneurs (percent)

	Ethiopia 1	Ethiopia 2	Uganda	Kenya	Mozambique	Nigeria	China	India
None	1.2	0.0	3.4	0.0	0.0	3.1	0.0	0.4
Primary	13.8	11.2	8.1	4.0	17.8	5.21	0.1	0.6
Secondary	26.4	12.1	19.8	23.2	44.1	10.8	15.2	9.8
Vocational	–	–	29.2	13.4	23.5	–	–	–
University	58.6	76.7	39.6	59.4	14.7	70.8	84.7	89.2
Experience (in years)	5.5	–	5.0	5.4	–	–	10.4	9.9
Foreign firm experience (%)	12.8	21.6	22.9	–	–	–	–	–

Source: Author's sample survey for Ethiopia (2004) and World Bank Investment Climate Assessment Report for Uganda (August 2004: 24).
Notes: (1) For owners of private firms only; (2) For general managers of both private and public enterprises; '–' Not available.

Establishment-level panel data were derived from the annual census of manufacturing enterprises conducted by the CSA. This census covers all manufacturing establishments employing at least 10 persons and using power-driven machinery. The database is highly confidential, however, and was made available to the researcher only upon official request. The relatively small number of manufacturing enterprises of the size mentioned and their concentration in and around the capital city Addis Ababa has enabled the CSA to carry out the census every year.[4]

The panel data contains all relevant information for productivity analysis. Each establishment was given a unique identification number in combination with a region code and a four-digit ISIC code. Data was collected on labour, intermediate inputs and their import component, beginning and end-of-period book values for different kinds of capital, energy consumption and other industrial and non-industrial costs. Labour data is presented in terms of number of employees by broad occupational categories and not in hours worked. In the absence of industry wholesale price indices, average output prices as reported by firms were used to construct firm- and industry-specific price indices. For firms with missing values on output prices the industry price index was used to deflate output and input values. Similarly, industry price indices were applied to deflate input costs and capital stock. The base year for the industry price index is 1996 (1995/96 is also the base year for the new consumer price index being used in the country). The time series on beginning and end-of-period capital stock reported by firms was inconsistent. For that reason a new series of capital stock was generated using the perpetual inventory method. A 5% depreciation rate was employed for buildings and a 10% depreciation rate for machinery and equipment.

As could be expected, the dataset was not without problems. The original number of observations was 5,167 firm-years for the 1996–2002 period. During the cleanup process, 171 observations (about 3%) were dropped for several reasons. These include missing data either on output or key inputs for the productivity analysis, non-unique firm identification numbers and observances where levels of inputs or outputs were extreme outliers. However, the problems were not concentrated in particular industries or years, and hence the exclusion of these observations is deemed unlikely to bias the analyses. The number of enterprises included in this study is 605 in 1996, increasing to 823 in 2002.[5]

While the CSA manufacturing census is ideal for the analysis of productivity and investment patterns, it was not designed to capture technological capabilities. Fieldwork was designed to fill this gap with a sample survey conducted from January to April 2004.[6] In the first stage, the sampling frame was obtained from the CSA based on the 2002 manufacturing census. This sampling frame contained 823 establishments that employ at least 10 persons with a total of 81,208 employees represented. In the second stage, the sampling frame was redefined to include 501 establishments located in and around Addis Ababa. In the third stage, four industries were purposely selected for the survey: textile and garments, leather and footwear, chemical and plastic and metal. The total number of establishments in these four industries in Addis Ababa was 210 in 2002. The first two industries are low-technology ones with a domestic resource base, while the latter two are medium-technology industries with considerable import intensity of inputs. Finally, stratified random sampling was used to select establishments from the sample frame. Each industry was stratified by firm size categories: small, medium and large. See table 2.2 for the firm size categories. Based on this strategy, data was collected on 127 establishments, making up 25.3% of the entire population of manufacturing establishments in Addis Ababa. This is 60.5% of all establishments in the four types of industries in Addis Ababa in 2002. Because of the bias toward large firms, the sample firms account for half of total manufacturing employment (in firms employing at least 10 persons) in Addis Ababa and 88% of total employment in the four industries in Addis Ababa in 2002. The fact that nearly two-thirds of manufacturing firms in Ethiopia are located in Addis Ababa suggests that the sample adequately represents Ethiopia's manufacturing sector.

Table 2.4 shows the size of each stratum and the optimal and actual sample sizes from each stratum. The optimal sample size indicates the distribution that would have prevailed in a self-weighted sample. As observed from the table, there is an over-sampling of medium-sized and, particularly, of large firms. This information was included in the data through the inverse of the sampling weights. The summary statistics reported in Chapter 5 use these weights.

Deviation from the optimal allocation of establishments in the stratified sample raised the standard error by about 5%. This appears much lower than the increase in standard error one would expect from the observed deviations, particularly for the large size category. Ironically, the deviation from the optimal allocation seems to have been a blessing in disguise in the sense that it over-samples the large firms category, which actually shows greater diversity than small

Table 2.4: Stratified sample and sample proportions

	Sample Size		Stratum Total	Sample Proportions	
TEXTILE & GARMENTS	Optimal	Actual		Optimal	Actual
Small	12	9	17	70.6	52.9
Medium	8	7	11	72.7	63.6
Large	10	14	15	66.7	93.3
Subtotal	30	30	43		69.8
LEATHER & FOOTWEAR					
Small	13	10	18	72.2	55.6
Medium	8	8	12	66.7	66.7
Large	7	10	10	70.0	100.0
Subtotal	28	28	40		70.0
CHEMICAL & PLASTICS					
Small	17	14	29	58.6	48.3
Medium	13	11	23	56.5	47.8
Large	8	13	13	61.5	100.0
Subtotal	38	38	65		58.5
METAL					
Small	18	12	36	50.0	33.3
Medium	8	9	16	50.0	56.3
Large	5	10	10	50.0	100.0
Subtotal	31	31	62		50.0
Grand Total	127	127	210	60.5	60.5

and medium-sized firms. The small firm category includes firms with 10 to 29 employees while the large firm category includes firms that employ at least 100 employees (in this category the maximum employment size is 2,342). The coefficient of variation of employment in small, medium and large firms is 0.47, 0.37 and 1.04, respectively, showing that the diversity in the large firm category is more than twice that in small firms and three times that in medium-sized firms. Although it was not a deliberate strategy, the outcome of the sampling exercise was the inclusion of more firms from a highly diverse group and less from a relatively homogeneous group – an outcome that reduces sampling error (Cochran 1977).

Notes to Chapter 2

1. The political economy literature is full of instances in which a weak state undermines growth as it fails to organise development and enforce laws. It is quite possible that in some instances, a strong state could also stifle growth, as strength leads to self-defeating actions that raise uncertainty (Bates 2000).
2. The difference between the two growth rates is not statistically significant.
3. Notice however that the firm-level surveys for other countries in table 2.3 cover the entire range of firm size (i.e. micro to large firms) while the Ethiopian survey includes only firms that employ at least 10 persons. The Ethiopian survey is also restricted to the capital city Addis Ababa. The average educational attainment of Ethiopian entrepreneurs is therefore likely to be biased upwards. Also notice that the university degree includes two-year

diploma programmes as well as the regular four-year and postgraduate degrees. In the first column, for instance, 34% of university graduates have only a two-year diploma.

4. In advanced countries like the United States, a manufacturing census is carried out every five years, with sample surveys filling the inter-census periods.
5. The author benefited from close cooperation with experts from the CSA in identifying problematic cases.
6. The sample survey follows the RPED (Regional Program on Enterprise Development) format used by the World Bank to collect manufacturing sector data in sub-Saharan Africa.

3 Market Selection and Productivity Dynamics[1]

3.1 Introduction

This chapter analyses market selection and its contribution to industrial competitiveness by looking closely at whether the processes of firm entry, survival and exit are driven by underlying differences in firm-level productivity. It also estimates the extent of producer turnover and reallocation of market share and their contribution to industry-level productivity growth. The chapter uses the census-based micro panel data from the CSA of Ethiopia. Some of the analyses are the first of their kind for a sub-Saharan African country. The stage is set by taking a closer look at the problems of African manufacturing that were highlighted in Chapter 1 and at some of the macro-level explanations offered in the literature.

As stated, the poor economic performance of sub-Saharan Africa is perhaps best revealed in its fragile manufacturing sector. It is the only developing region that had a declining ratio of manufacturing value-added to GDP during the 1990s. Although the region has never been an important player in export markets, its share in manufactured exports originating from the developing world has declined since the 1970s. It is also the only region in the world that does not exhibit a shift in the technological composition of its exports from natural resource-based and low-technology products to high-technology commodities.

The industrial landscape of African economies is dominated by micro-enterprises in the informal sector, whose role in economic growth has been the subject of a number of firm-level studies. A key finding of these studies is that micro-enterprises have not so far served as a seedbed for modern small and medium-sized enterprises (SMEs), a situation particularly evident in Africa. Modern small enterprises (with more than 10 employees) seldom evolve through the size structure but rather emerge in and remain in this size category (Liedholm 1990). Moreover, unlike in developed countries, where the number of small enterprises increases with overall economic activity, it is uncertain whether the same holds true in developing counties. Rather, their number tends to increase during periods of recession and economic shocks, casting doubt on their sustainability (Liedholm and Mead 1999). Most if not all micro-enterprises derive their competitiveness from their ability to evade laws and regulations, implying that a reduction of regulatory requirements may lead to their disappearance (Fafchamps

1994). Governmental and non-governmental organisations generally make efforts to help micro-enterprises, essentially as a poverty alleviation strategy. A viable long-term development strategy, however, must reach beyond targeted anti-poverty programmes to address issues of competitiveness and industry dynamics in a liberalised environment; an issue addressed in this study.

Even the formal and relatively modern segment of manufacturing in Africa has a long way to go to become internationally competitive and serve as a driver of long-term growth. Manufacturing value-added as a share of GDP has either stagnated or declined in most African countries in recent years. For the region as a whole, manufacturing's share declined during the 1990s (figure 3.1),[2] leading some researchers to believe that de-industrialisation was taking place in Africa (Noorbakhsh and Paloni 1998). Given that most African countries have implemented ongoing economic reform programmes since the mid-1980s, the decline in the importance of a supposedly progressive sector is disconcerting.

Table 3.1 shows that only 14 out of 50 countries experienced an increase in the ratio of manufacturing valued-added to GDP after 1985 relative to the average for the period 1960–1985. For the remaining 70% of countries, the share of manufacturing has either stagnated or declined. Most importantly, there has been drastic slowdown in the average growth rate of manufacturing value-added since the mid-1980s even in countries where the share of manufacturing in GDP has increased. For East Asian economies this was the period in which manufacturing gained importance and became technologically advanced.

African countries performed badly in the export of manufactured products as well. The region's share in total manufactured exports from the developing

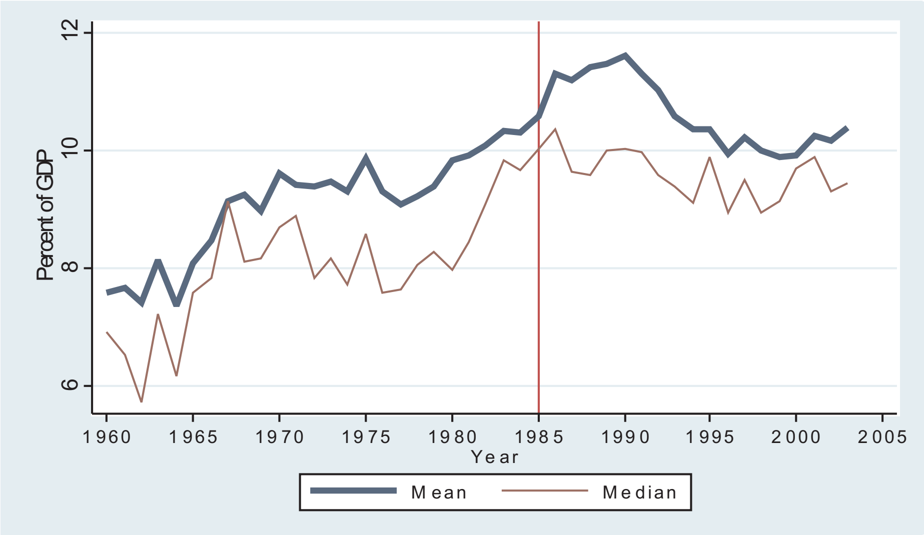


Figure 3.1: Manufacturing value-added to GDP ratio in sub-Saharan Africa (unweighted)
Source: World Bank's World Development Indicators (2005).

Table 3.1: Manufacturing value-added average growth rate and ratio to GDP

	Countries Where Manufacturing Value-added to GDP Ratio						All Countries	
	Increased1		Stagnated[1]		Declined1			
	Growth	GDP Share	Growth	GDP Share	Growth	GDP Share	Growth	GDP Share
1960–1985	8.7	12.7	6.0	8.7	6.1	10.5	6.8	10.1
1986–2000	4.8	16.0	3.1	8.8	0.6	7.9	3.5	10.6
No of Countries	14		23		13		50	

Source: Author's computations based on World Bank World Development Indicators (2005).
Note: (1) Based on a linear time trend.

world declined from 5% in the 1970s to less than 2% in recent years. Unsurprisingly, the gradual increase in the technological content of manufactured exports observed in the developing world is completely missing in the African context. Figures 3.2 and 3.3 show that developing countries in general and Asian economies in particular have been moving away from resource-based and low-technology manufactured exports toward high- and medium-technology commodities over time. This shift has been particularly impressive in Asia, where the share of high-technology exports accounted for more than one-third of total manufactured exports and exceeded the share of both natural resource-based and low-technology exports after 1998. Despite some limitations, this transition indicates the technological capabilities and long-term competitiveness of economies (Lall 2001). The appendix to this chapter (tables 3A.1 and 3A.2) describes the technological classification of exports and their characteristics.

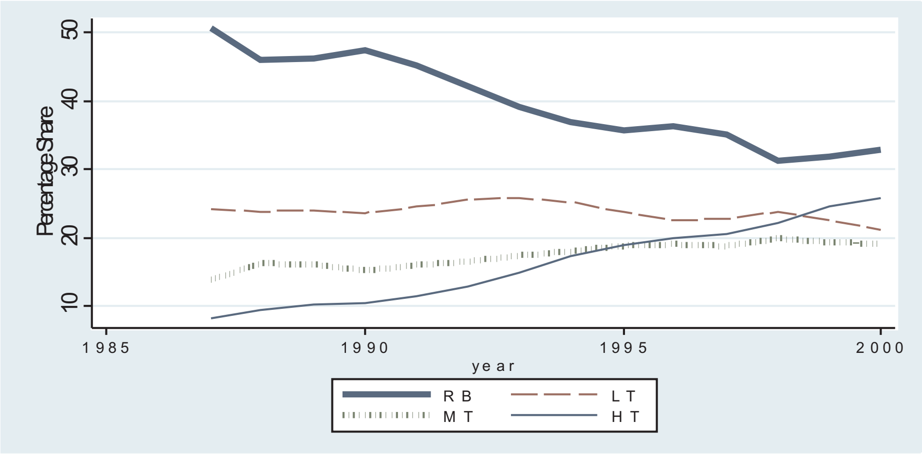


Figure 3.2: Technological structure of developing countries' manufactured exports
Source: UNCTAD Handbook of Statistics online.
Key: RB = resource-based manufactured exports; LT = low-technology manufactured exports; MT = medium-technology manufactured exports; HT = high-technology manufactured exports.

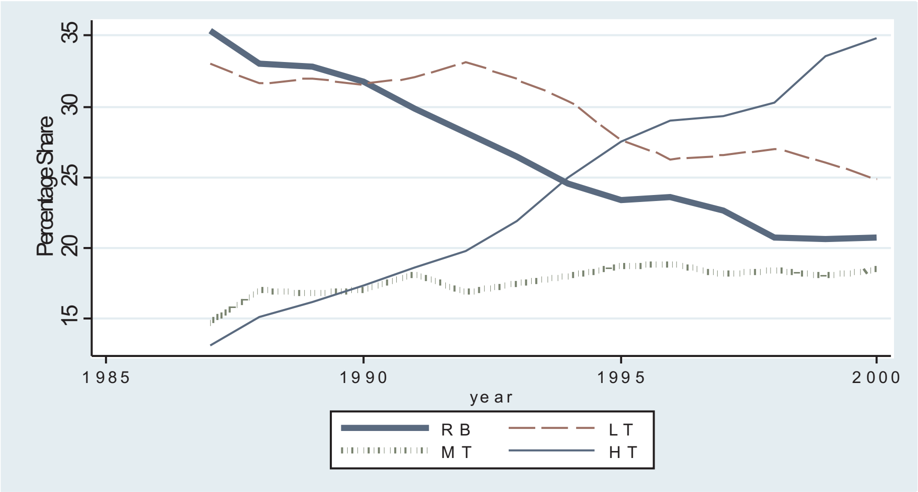


Figure 3.3: Technological structure of Asian manufactured exports
Source: UNCTAD Handbook of Statistics online.
Key: See figure 3.2.

The situation in Africa is rather bleak; the region's exports are overwhelmingly resource-based and the entire structure suffers a lack of dynamism (figure 3.4).

Explaining the problem

Most economists agree that developing countries in general have structural features that constrain their rate of industrial progress. These include small domestic markets, dependence on imported inputs/capital, low levels of human capital and poor infrastructure. Other factors relate to government policies in terms of macroeconomic stability and policy predictability (Tybout 2000). There is little disagreement that these problems are pervasive in sub-Saharan Africa.

The underlying assumption of arguments that emphasise market size is the importance of scale economies for industrial progress. If domestic demand for manufactured items is small and markets are fragmented because of poor infrastructure, firms will tend to be diminutive and unable to benefit from returns enjoyed by those with a larger scale of operation. Low incomes limit local demand to basic consumption goods, such as food and clothing (the Engel effect), produced by industries not characterised by increasing returns to scale technologies. Moreover, technological possibilities for such industries are rather restricted and less progressive, limiting the scope for long-term productivity growth. Indeed, empirical studies have found little significance of scale economies in such manufacturing. Econometric estimates based on small enterprises as well as samples that also include large enterprises show constant or only mildly increasing returns to scale (Biggs et al. 1995; Little, Mazumdar and Page 1987).

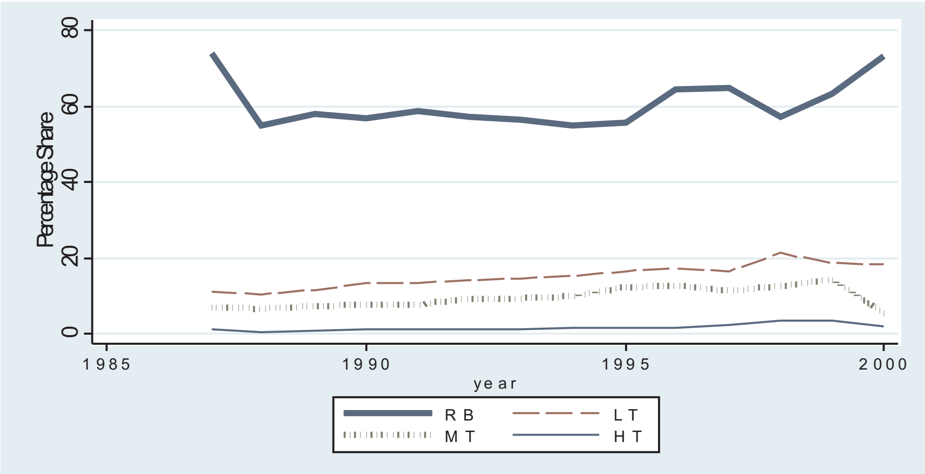


Figure 3.4: Technological structure of African manufactured exports
Source: UNCTAD's Handbook of Statistics online.
Key: See figure 3.2.

The implication is that the dominance of small enterprises in developing countries may not be as serious a problem as is often thought in the simulation-based literature (Tybout 2000).

Export orientation supposedly provides countries a "way out" from limited domestic markets, as witnessed in East Asian economies. This is at the heart of the Keynesian argument that focuses on demand for exports as a source of growth (Kaldor 1970). While this view is still relevant, export growth is not an exogenous factor. Initial levels of human capital and other technological capabilities determine how successful countries can be in adopting new technologies and producing products in high demand in international markets. Competitiveness in export markets is also affected by the availability and quality of domestic infrastructure. Companies in developing countries are at times forced to provide their own facilities (power and water, for instance), which on top of higher transport and other service costs seriously damages their competitiveness. Apart from the scale effect, exports are believed to provide learning externalities that enhance productivity. However, the available evidence is mixed regarding the role of exports in productivity growth. Although in most cases exporting firms are more productive than firms serving only domestic markets, part of the story is efficient firms self-selecting to serve export markets. Bigsten et al. (1999) controlling for self-selection in export markets showed that for a group of four sub-Saharan African countries there is "learning by exporting". It is yet to be seen if this observation is generally true for other countries in the region.

Apart from the structural issues highlighted above, a number of policy-related arguments explain economic growth in general with implications for industrial development. In the past, the externalities expected from industrial development and the infant industry argument motivated developing countries to follow protective trade policies. However, the failure of the import-substituting industrialisation strategy led to the rise of openness and liberalisation as the new orthodoxy. Its wide acceptance was grounded on the promise of technical efficiency and upgrading. However, whether variation in productivity growth and industrial success across countries and over time are strongly associated with the choice of trade policy remains a question with no clear answer.

From a theoretical point of view, it is clear that trade theory does not provide a strong foundation for free trade policy on the basis of technical efficiency gains (Rodrik 1992). Short of a general theoretical presumption, however, there are a number of arguments in support of trade liberalisation for efficiency purposes.

One such argument is the reduction of X-inefficiency with trade liberalisation. This is supposedly realised as increased foreign competition induces more entrepreneurial effort to innovate, to cut costs and to acquire technological capabilities. The assumption is that entrepreneurs choose the "quiet life" in the absence of foreign competition, leading to a productivity slowdown (Balassa 1988). However, if this argument is to hold water a number of assumptions need to be made, including weak domestic competition, a backward-bending labour supply curve for managers and a substitution effect larger than the income effect (Cordon 1994). Apparently, there is little empirical support for these assumptions, particularly in developing countries, although there appears to be convergence toward the mean industry practice following trade liberalisation, i.e., reducing the variance in productivity.

The other important argument for liberalisation is based on the observation that inward-oriented economies are prone to stop-and-go policies that instigate macroeconomic instability. As such, productivity growth suffers under macroeconomic instability and fluctuations of import levels that undermine capacity utilisation as well as the incentive to upgrade technology. Liberalisation is expected to reverse this situation by promoting stability, improving reserve positions and enhancing capacity utilisation as availability of imported inputs improves (Pack 1992). Yet, while it is often true that the level and stability of macroeconomic incentives affects productivity growth, this does not necessarily constitute an argument for trade liberalisation in the strict sense of the term. Productivity declines due to a volatile macroeconomic environment should be dealt with by macroeconomic policy and not trade policy reform (Rodrik 1992).

The new trade theories bring to the surface the original thinking on the gains from free trade, i.e., specialisation and cultivating dynamic scale economies. By opening global markets for domestic firms, liberalisation was said to permit exploitation of increasing returns to scale. The static benefits from trade could be compounded by productivity growth if trade liberalisation led to the emergence or expansion of industries featuring increasing returns to scale technologies. The catch is that there is no guarantee that these possibilities will be realised. There is a strong emphasis on exports in this argument, which also happens to be its weak-ness. Protection cannot be considered the major reason why domestic firms do not take advantage of export markets if they offer increasing returns. In actuality, exports of manufactured goods from some developing countries started to grow well before trade liberalisation. On the other hand, if import-competing industries are also the ones that exhibit increasing returns to scale technologies, then trade liberalisation cannot ensure productivity gains because of falling market shares (Rodrik 1988).

Most of the empirical evidence linking trade policy with technical efficiency has been inconclusive so far. What makes these studies even less useful is not so much their inconclusive findings but rather their failure to distinguish macroeconomic policy from trade policy. Coming back to our point, little light has been shed by efforts to trace poor industrial performance in sub-Saharan Africa to protectionism or incomplete liberalisation.

Although developing countries have tended to protect their manufacturing industries, they also generally have burdensome administrative mazes that stifle firm entry, growth and exit. A recent body of theoretical and empirical literature argues that hampering these processes of firm dynamics is likely to reduce aggregate (industry-level) productivity growth if such processes are indeed driven by underlying differences in efficiency. In other words, even in the absence of scale economies, industries can experience productivity growth if technological heterogeneity predisposes more productive firms to grow while forcing inefficient firms to contract and exit. Any government policy that reduces entry and exit barriers and enhances competition (including trade policy) is therefore likely to lead to productivity growth.

According to this argument, sluggish industrial growth in sub-Saharan Africa and other developing countries is thus partly explained by weak market selection, which tolerates inefficient firms (Collier and Gunning 1999). In a review of manufacturing firms in developing countries, Tybout remarked:

> If extensive regulation and taxation combine with credit market problems to keep small firms from challenging their entrenched larger competitors, we should observe few firms graduating from informal to formal status. Further, those firms that graduate should show relatively little mobility up the size distribution and market shares should be relatively stable among the largest firms (2000: 25).

Earlier attempts to test these hypotheses in Africa found high rates of producer turnover in the micro and small enterprises sector with growing firms standing a better chance of survival (Liedholm and Mead 1999, McPherson 1995). This suggests a competitive environment. However, other observations by the same authors, such as the fact that most firm closures happen for non-business reasons, that the exit hazard does not decrease with firm size and that firms seldom graduate to the formal sector (with 10 workers or more), imply that firm dynamics in Africa may not be strongly driven by market selection. Recent studies that focus on the manufacturing sector only but employ a broad range of firm sizes found that small firms grow faster than larger ones and the exit probability is higher among small and inefficient firms. These conclusions support the implications of market selection models (Gunning and Mengistae 2001; Frazer 2005; Söderbom, Teal and Harding 2006). However, key assumptions of market selection models, particularly on the reallocation of resources and the contribution of producer turnover, remain unexplored in sub-Saharan Africa, mainly because of the absence of reliable industrial census data and partly due to the confidentiality problem that restricts access to such data (Gunning and Mengistae 2001).

This chapter contributes to filling this gap. Using a census-based panel of manufacturing establishments in Ethiopia, it examines the heterogeneity in firm-level productivity and whether this heterogeneity drives observed patterns of entry, exit and survival. Most importantly, it estimates the magnitudes of producer turnover and reallocation of resources from less efficient to more efficient producers, and their respective contributions to industry-level productivity growth. In doing so, the chapter addresses two central questions:

- How strongly do African markets, as represented by Ethiopia, select efficient firms?
- Does market selection play an important role in long-term industrial progress?

This is the first attempt, as far as this author is aware, to test the assumptions of market selection models based on manufacturing census data for a sub-Saharan African economy. The organisation of the chapter is as follows. Section 3.2 briefly reviews the theoretical and empirical literature on market selection. Section 3.3 discusses the nature of the data and estimation methods. Section 3.4 presents the evidence on firm exit, entry and survival using productivity transition matrices. Section 3.5 discusses alternative methods of decomposition of productivity growth and the corresponding results. Section 3.6 examines shifts in the distribution of productivity over time, and section 3.7 draws conclusions.

3.2 Literature on market selection

3.2.1 Dynamic theories of industrial evolution

There is ample evidence showing that total factor productivity (TFP) growth is a major driver of economic growth both in developing and developed countries, with its role being slightly higher in the latter than in the former (Chenery et al. 1986). However, a major theoretical and empirical challenge in the growth literature is identification of the sources of productivity growth.

Analyses of productivity growth, either in the growth accounting framework or in relation to trade policy, suffer a methodological problem. Most studies rely on aggregate-level productivity estimates which assume that all firms in an industry, sector or country employ the same technology and respond to shocks, such as changes in relative prices, in a similar fashion. Under such a representative firm approach, productivity growth is regarded as an orderly shift in technology across all firms. Empirical observations based on the increasing availability of industrial census data disclose a completely different reality. Even within a narrowly defined industry and within a given macroeconomic and institutional framework, firms exhibit a considerable degree of heterogeneity in size, capital intensity and profitability (Tybout 1991). This diversity seems to sustain an autonomous state of flux even in the absence of any change in relative prices. Some firms grow while others contact; some firms enter an industry while others exit. It is therefore futile to attempt to capture true productivity dynamics at the industry level with the representative firm approach (Nelson 1981). Not only is there no single production function, but productivity growth involves a process of learning, innovation, investment, entry and exit rather than a smooth shift across all firms (Roberts and Tybout 1996). The evidence from micro-level studies also suggest that policies can influence industry-level productivity through their effect on market selection even when technology does not exhibit increasing returns.

There are several explanations for the existence of firm-level heterogeneity and how it is linked to aggregate productivity. Some of them are in a general equilibrium framework while others follow a partial equilibrium approach. General equilibrium analysis pays attention either to the rate at which new products are introduced in an economy (Lucas 1993) or the rate at which low-quality products are progressively replaced by higher quality ones (Stokey 1991). This chapter focuses on partial equilibrium models, which have testable hypotheses at the firm level in relation to aggregate productivity dynamics.

Significant progress has been made in explaining firm heterogeneity in productivity using dynamic partial equilibrium models. These models recognise technological heterogeneity as a major source of inter-firm productivity differences. One such model is the passive learning model suggested by Jovanovic (1982). In this model producers learn about their endowments of relative efficiency by participating in the market. Firms that receive positive productivity shocks expand and achieve their true level of productivity, growing in size in the process. Firms that learn they are relatively inefficient contract and eventually exit. Therefore, even in competitive product markets, firms of varying levels of productivity can coexist, because it takes time to discover one's true efficiency. This model has important testable implications: growth is relatively faster among small firms, which are also relatively less productive and more likely to exit. For a given age cohort, the model predicts the survival rate will be higher among large firms, which will also exhibit relatively narrow productivity differences.

This is unlike the model by Lucas (1978), according to which firms have accurate knowledge of their relative efficiency prior to entry. According to Lucas, this difference does not disappear over time and generates a skewed distribution of firm size reflecting heterogeneous productivity originating from permanent differences in managerial talent. Hopenhayn (1992) provides a model in which productivity differences persist over time, mainly because the competitive advantages acquired by firms (for whatever reason) are not quick to diminish. In this model, a large productivity shock in the current period increases the probability of the firm experiencing a larger productivity shock in the next period. Hopenhayn's model also suggests that simultaneous entry and exit of firms with offsetting results would take place with sufficiently low sunk entry cost. However, the latter would also increase competitive pressure on incumbents and hence lead to productivity growth at the industry level. This means, even though entry and exit may not have a significant immediate impact on aggregate productivity, because of their size and the cancelling out effect, they may have important implications in the long run (Tybout 1996). Policies that raise entry cost may therefore lead to uncompetitive industries by protecting incumbents from market selection.

The models discussed above abstract from firm-level efforts to enhance productivity. Ericson and Pakes (1995) developed a market selection model that incorporates firm-level investments in productivity-enhancing activities. The source of heterogeneity is therefore idiosyncratic shocks or uncertainties as to the outcomes of these investments. In their model, profitability tends to decline if firm-level efforts to improve their profit-earning capability (upgrading product quality, improving production organisation and techniques, exploring new market channels, etc.) are unsuccessful. Eventually the firm reaches a point where it is optimal to abandon the business. Therefore, the decision to exit is conditional on returns to productivity-enhancing efforts. If such innovation succeeds, the firm moves up in the productivity distribution of the industry in which it operates.

Heterogeneity arises not only because of differences in returns to investments in technology, but also because of the effect of uncertainty on decisions on whether to invest. Dixit (1989) showed that an unpredictable incentive regime increases entrepreneur reluctance to invest in technology. This means that firms at different technological levels could coexist in the market, reflecting differences in the vintage of different cohorts of firms. Policy predictability would thus affect the rate of change of productivity.

Jovanovic and MacDonald (1994) provided a competitive diffusion model, in which innovation and imitation are alternative and costly sources of productivity growth, and the relative desirability of each depends on the current know-how of the firm as well as the state of knowledge of the industry. One implication of this model is that small firms tend to grow faster than large firms because their probability of success from a given learning effort is greater for the former than for large technologically leading firms.

3.2.2 Empirical studies of industrial evolution

The theoretical literature on market selection has served as an organising framework for a number of empirical studies that assess the link between firm dynamics and aggregate performance. The empirical literature can be divided into two broad categories: those studies that test the assumptions of market selection models and those that test their implications. Studies that assess the assumptions of market selection models are based on industrial census data and tend to be limited to industrialised countries. Few such studies are available from semi-industrialised developing countries. Absence of reliable industrial census data coupled with the confidentiality problem has so far prevented the testing of the assumptions of selection models in sub-Saharan Africa (Gunning and Mengistae 2001).

On the other hand, several empirical studies have assessed the implications of market selection models. For Ethiopian firms, for instance, see Gunning and Mengistae (2001) and Mengistae (1995). Such studies test the age and size effects on firm growth to find out which proposition of selection holds in a particular circumstance. Such studies almost invariably find evidence that support the passive learning model of Jovanovic (1982); i.e., small firms tend to grow faster than large firms, though they also tend to exit the market more often than large firms. Growth also declines with age, but older firms are more productive and less likely to exit than younger ones. Evidence from these studies suggests that African markets do exercise competitive selection.

Studies that assess the assumptions of market selection models, on the other hand, seek evidence for the existence and extent of productivity differences among entrants, exiting firms and incumbents, or between exporters and non-exporters. They also investigate whether there is reallocation of resources and market shares away from less efficient firms to more efficient ones. The evidence in this respect is more complex and difficult to summarise. A common finding is that incumbents are more productive than both exiting firms and new entrants, with the latter two largely found at the lower end of the productivity distribution. In Taiwanese manufacturing, for instance, entrants were less productive than incumbents in seven out of nine industries, and the average productivity of exiting firms was less than that of continuing firms for every industry and time period studied (Aw et al. 2001). The role of net entry for industry-level productivity growth in Taiwan was also key, ranging between 1% and 35%. Aw and colleagues found intra-firm productivity growth (the "within effect") to also be much more important and closely related to the pattern of productivity growth in an industry. In the United States, net entry had no significant role in aggregate productivity, even acting as a net drag at times (Baily et al. 1992). However, the study by Baily and colleagues found both exiting and entering firms to be less productive than incumbents.

The divergence of evidence is even more stark regarding the importance of productivity reallocation, i.e., reallocation of resources and market share among continuing firms based on productivity differences. The literature from developed countries finds evidence of a positive and significant effect of market share reallocation. Baily et al. (1992) show that such reallocation contributed 30% to 40% of industry-level productivity growth during periods of productivity improvement and helped to offset sharp declines during periods of productivity loss. Bernard and Jensen (1999) found similar evidence for US firms, for which the reallocation effect was greater than 40%. For Taiwan, the reallocation effect was close to zero (Aw et al. 2001). In Colombia, reallocation had little long-run effect on aggregate productivity growth, despite substantial year-to-year differences (Liu and Tybout 1996).[3] Like Aw and colleagues, Liu and Tybout found the "within effect" (intra-firm) to be significant in explaining industry-level productivity changes in Colombia. On the other hand, Pavcnik (2002) reported that about 70% of productivity growth in Chilean manufacturing is explained by reallocation of resources from less efficient to more efficient firms. More recently, Petrin and Levisohn (2004) found a positive and significant role of reallocation for Chilean firms based on an alternative decomposition method that is also used here. Comparing these results is complicated, however, by differences in decomposition methodology, the weights used for aggregation and the industries studied.

This chapter provides empirical evidence from sub-Saharan Africa that can be readily compared with the evidence presented above. Such an exercise has so far been hindered by differences in the nature and composition of samples thus far used in firm-level studies in Africa. For instance, the work by Liedholm and Mead (1999) and McPherson (1995) left out the medium and large size categories and used a mixture of manufacturing and service industries. Frazer (2005) and Söderbom et al. (2006) showed the importance of efficiency for firm survival, yet did not establish the link between firm and industry dynamics. Moreover, their sample was drawn from a few manufacturing industries and with large firms heavily represented. Using similar data, Van Biesebroeck (2005) went further, to investigate firm size and productivity dynamics using transition matrices and decomposition of aggregate productivity growth based on panel data of surviving manufacturing firms. He found persistence in the distribution of firm size and efficiency, and that intra-firm productivity growth dictates industry-level productivity growth much as in other developing and developed countries.

As indicated, this chapter analyses firm and industry dynamics using census-based panel data. This facilitates direct comparison with benchmarks in the literature, as census-based panel data allow not only the estimation of producer turnover and its contribution to aggregate productivity growth but also more accurate estimation of the resource reallocation role of markets.

3.3 Estimation of productivity

An important assumption of dynamic models of industrial evolution is the relationship between productivity shocks and input levels. Productivity shocks constitute part of the information that firms need to decide whether to stay in a market as well as input levels if they do continue to operate. The correlation between input levels and firm-specific productivity shocks that are unobservable to the researcher creates a simultaneity problem. Estimation methods that ignore this correlation (like OLS) yield biased and inconsistent factor elasticity estimates. Hence, productivity analysis based on such estimates will also be unreliable.

Earlier attempts to solve this problem used a fixed effects estimation method on a panel of firms that sweeps away any association between firm-specific fixed effects and input levels. While this method minimises the simultaneity bias, it assumes, as the name indicates, that the unobserved effects vary across firms but remain time-invariant. There is however much interest in time-varying idiosyncratic shocks, as they allow empirical testing of policy outcomes as well as of the implications and assumptions of theories on industrial evolution. Researchers have attempted to achieve this by regressing the fixed effects as some function of time. There are two approaches along these lines, both in the stochastic frontier production function tradition. The first, by Cornwell et al. (1990), starts by estimating a fixed effects model, the residual of which is regressed against time and time squared. The models can be represented as follows:

$$\begin{aligned} Y_{it} &= \beta_0 + \beta x_{it} + \beta_k k_{it} + \eta_{it} + u_{it} \\ \eta_{it} &= \alpha_1 + \alpha_2 t + \alpha_3 t^2 \end{aligned} \tag{1}$$

where η_{ti} is the productivity term and u_{ti} is the standard zero mean and constant variance residual. While this approach makes the productivity term vary over time, it remains an arbitrary choice of time function with little economic sense.

Another approach in the stochastic frontier production function for a time-varying efficiency term runs as follows:

$$Y_{it} = f(x_{it}, \beta)\lambda_{it} \exp(v_{it}) \tag{2}$$

where λ_{it} is the level of efficiency for firm *i* at time *t* and lies in the interval (0,1), whereas v_{it} is a purely random shock that includes measurement errors. Equation (2) can be expressed in logarithmic terms as follows:

$$\ln Y_{it} = \ln\{f(x_{it}, \beta)\} + \ln \lambda_{it} + v_{it} \tag{3}$$

Given the range of λ_{it} we can define $u_{it} = -\ln \lambda_{it}$ and express the equation as

$$\ln Y_{it} = \ln\{f(x_{it}, \beta)\} + v_{it} - u_{it} \tag{4}$$

In a time-invariant model $u_{it} = u_i$, but for a time-varying approach Battese and Coelli (1992) chose a particular function of time that multiplies the fixed effect:

$$u_{it} = \exp\{-\eta(t-T)\}u_i \quad (5)$$

where T_i is the last time period for a particular firm and η is a decay parameter ($\eta = 0$) would amount to a time-invariant model). Again in this definition the time-varying element is derived from the time-invariant efficiency term with a particular function of time which has little economic implication.

Olley and Pakes (1996) proposed an innovative approach using investment as a proxy for unobserved effects. They defined a production function with two error components: one representing white noise and another representing a firm-specific productivity shock. They modelled investment as a non-decreasing function of the productivity shock and other state variables. By inverting the investment function, they defined a functional form for estimating productivity. The Olley-Pakes approach is considered to provide a better solution to the simultaneity problem compared to the fixed effects and GMM estimators as it leaves more identifying variance in inputs and exogenous variables (Griliches and Mairesse, 1998).[4] However, since the Olley-Pakes approach requires non-zero investment, it truncates firms with no investment. Its application to firm-level data from developing countries is thus limited, as nearly 50% of firms do not invest in a given period. Moreover, the presence of adjustment costs in investment implies that the proxy may not catch the whole productivity shock.

Following the same strategy as Olley and Pakes (1996), Levinsohn and Petrin (2003) devised a model that uses intermediate inputs as a proxy for unobservables. One important advantage of this method is that it avoids truncating firms with zero investment since almost all firms do use intermediate inputs. In addition to the data advantage, the Levinsohn-Petrin method also picks up a substantial proportion of productivity shocks, as intermediate inputs are relatively easier to adjust than investment. The fact that intermediate inputs do not form part of the state variables that determine the relative position of a firm in an industry also makes them good proxy variables. The productivity estimates used in this chapter are obtained by applying this procedure to the value added by Ethiopian manufacturing firms.

The estimation of firm-level TFP in this study follows the Levinsohn-Petrin method. The production function with two error components is written as follows:

$$y_t = \beta_0 + \beta_l l_t + \beta_k k_t + \beta_m m_t + w_t + \eta_t \quad (6)$$

where y_t represents the logarithm of firm-level gross revenue or value-added; l_t and m_t are the logarithms of labour and other freely variable intermediate inputs; and k_t is the logarithm of state variable capital. The subscript i is suppressed for ease of expression.

To overcome the simultaneity bias, Levinsohn and Petrin (2003) assume demand for intermediate inputs to be a function of the state variables k_t and w_t:

$$m_t = m_t(k_t, w_t) \quad (7)$$

Assuming demand for intermediate inputs as monotonically increasing in productivity w_t, one can invert equation (7) to get a functional form for w_t as follows:

$$w_t = w_t(k_t, m_t) \tag{8}$$

Equation (8) now expresses the unobserved productivity term as a function of two observables. This term is substituted into equation (6).

A final identification restriction requires a first-order Markov process for the productivity term, following Olley and Pakes (1996):

$$w_t = E[w_t | w_{t-1}] + \xi_t \tag{9}$$

where ξ_t is innovation to productivity that is not correlated with k_t, but not necessarily with l_t; Levinsohn and Petrin identify this as part of the source of the simultaneity problem.

In a value-added production function, equation (6) takes the following form:

$$v_t = \beta_0 + \beta_l l_t + \beta_k k_t + w_t + \eta_t \tag{10}$$

Using the inverted demand function for intermediate inputs from equation (8) and substituting it into equation (10) yields the following:

$$v_t = \beta_0 + \beta_l l_t + \phi_t(k_t, m_t) + \eta_t \tag{11}$$

where $\phi_t(k_t, m_t) = \beta_0 + \beta_k k_t + w_t(k_t, m_t)$.

By substituting a third-order polynomial expansion in k_t and m_t in place of $\phi_t(k_t, m_t)$, it is possible to find a consistent estimator of the parameters of the value-added equation using OLS:

$$v_t = \delta_0 + \beta_l l_t + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \delta_{ij} k_t^i m_t^j + \eta_t \tag{12}$$

where β_0 is not separately identified from the intercept of $\phi_t(k_t, m_t)$. This first-stage estimation provides a consistent estimate of β_l that is not contaminated with the correlation of labour with current period productivity. It also gives an estimate of $\phi_t(k_t, m_t)$. However, since k_t appears twice in $\phi_t(k_t, m_t)$ it is not identified without further restrictions.

The second stage, therefore, begins by computing the predicted value of ϕ_t from (12):

$$\hat{\phi}_t = \hat{v}_t - \hat{\beta}_l l_t$$
$$= \delta_0 + \sum_{i=0}^{3} \sum_{j=0}^{3-i} \hat{\delta}_{ij} k_t^i m_t^j - \hat{\beta}_l l_t$$

For any candidate value of β_k^* (say from a Cob-Douglas production function) a predicted value for w_t can be estimated using

$$\hat{w}_t = \hat{\phi}_t - \beta_k^* k_t \qquad (13)$$

With these values, a consistent non-parametric approximation (locally weighted regression) to $E\left[w_t \mid w_{t-1}\right]$ is given by the predicted values from the regression:

$$\hat{w}_t = \gamma_0 + \gamma_1 w_{t-1} + \gamma_2 w_{t-1}^2 + \gamma_{t-1}^3 + \varepsilon_t \qquad (14)$$

Levinsohn and Petrin (2003) call this $E\left[w_t \,\hat{|}\, w_{t-1}\right]$.

Given $\hat{\beta}_l$, β_k^* and $E\left[w_t \,\hat{|}\, w_{t-1}\right]$, Levinsohn and Petrin write the sample residual of the production function as follows:

$$\hat{\eta}_t + \hat{\xi}_t = v_t - \hat{\beta}_l l_t - \beta_k^* k_t - E\left[w_t \,\hat{|}\, w_{t-1}\right] \qquad (15)$$

The estimate for $\hat{\beta}_k$ of β_k is defined as the solution to

$$\min_{\beta_k^*} \sum_t \left(v_t - \hat{\beta}_l l_t - \beta_k^* k_t - E\left[w_t \,\hat{|}\, w_{t-1}\right]\right)^2 \qquad (16)$$

The further analyses in this chapter use firm-level productivity estimates derived from the application of the Levinsohn-Petrin method to a panel of Ethiopian manufacturing firms for the period 1996–2002. The dependent variable is value added and the production function is estimated for nine industries separately, following the procedure outlined in Petrin, Poi and Levinsohn (2004).

Once the coefficients of the value-added production function are estimated as outlined above, TFP is estimated as follows:

$$TFP_{it} = \exp\left(w_{it} + \eta_{it}\right) = \exp\left(y_{it} - \beta' x_{it}\right) \qquad (17)$$

3.4 Firm heterogeneity and producer turnover

Theories of market selection presume that firms within a narrowly defined industry exhibit considerable heterogeneity, which is underpinned by efficiency differences. Research based on micro-data both in developing and developed countries lends support to this presumption. The benefits of using micro-data over the traditional representative firm approach could, however, be attenuated by doubtful data quality, particularly with regard to data from developing countries. One is left wondering how much of firm-level heterogeneity is pure measurement error and how much is technology related (Bartelsman and Doms 2000). To answer this question, evidence must be sought by examining patterns of firm entry, exit and survival, as well as reallocation of market share vis-à-vis productivity differentials.[5]

Using the TFP estimates from section 3.3, table 3.2 compares selected percentiles from the distribution of productivity relative to the 90^{th} percentile. Like in other countries, Ethiopian manufacturing industries show considerable heterogeneity in firm-level efficiency. At the level of the manufacturing sector in general

Table 3.2: Firm heterogeneity in productivity, comparison to the 90th percentile (as percentages of the 90th percentile)

Industry	**Percentiles**			
	10th	**25th**	**50th**	**75th**
Food & Beverage	5.6	11.2	24.7	51.0
Textile & Garments	2.6	6.5	13.1	34.7
Leather & Footwear	4.0	10.0	18.0	38.1
Wood & Furniture	6.4	12.1	22.5	44.3
Printing & Paper	10.2	19.2	32.2	52.6
Chemical & Plastic	3.6	8.2	17.2	42.9
Non-Metal	4.5	10.5	20.8	42.9
Metal	5.0	10.7	17.7	39.0
Non-Light Machinery	7.3	13.6	25.0	44.4
Manufacturing Sector	5.3	11.0	21.8	45.8

Source: Author's computations based on CSA data.

(the last row), the 10^{th} percentile is about 5% as productive as the 90^{th} percentile, while the median firm is only 22% as productive. On the other hand, the 90^{th} percentile is more than twice as efficient as the 75^{th} percentile. Industry-specific differences in this pattern of distribution are rather limited. The only exception is the printing and paper industry, where the relative productivity of the 10^{th} and 25^{th} percentiles are nearly twice the respective sectoral averages showing relatively narrow productivity dispersion in this industry.

The importance of this heterogeneity in driving the survival and exit of producers is explored by way of constructing transition matrices following Baily, Hulten and Campbell (1992). These matrices trace the movement of firms along the ranks of productivity distributions during the study period. Table 3.3 (*a* and *b*) show this transition from 1996 to 2002.[6] Firms are ranked and divided into quintiles based on productivity indices in 1996 and 2002. The most productive quintile is quintile 1 in both tables and years and the least productive firms are in quintile 5. The tables are for the entire manufacturing sector; the fact that the analysis is based on an index rather than the level of productivity allows inter-industry and across-time comparisons. Table 3.3*a* is read row-wise and table 3.3*b* column-wise. Accordingly, table 3.3*a* depicts the proportion of firms from each productivity quintile in 1996 that ended up in different quintiles in the 2002 distribution including those firms that exited. On the other hand, table 3.3*b* displays the composition of firms in the 2002 distribution by tracing their origin from different quintiles in 1996, including new entrants. Each row in table 3.3*a* adds up to 100 while each column adds up to 100 in table 3.3*b*.

Table 3.3a shows a substantial degree of persistence at the upper end of the productivity distribution while the bottom end is in a state of flux. Close to 40% of firms that were in the 1st quintile in 1996 managed to stay in the 1st quintile after six years, while another 20% slipped to the 2nd quintile. Taken together,

Table 3.3: Transition of firms based on unweighted productivity index in 1996 and 2002

a. Destination of firms observed in 1996

	Quintiles in 2002							US Exit Rate
Quintiles in 1996	**1**	**2**	**3**	**4**	**5**	**Exit**	**Total**	
1	38.8	19.8	9.9	4.1	1.7	25.6	100	14.0
2	21.5	15.7	11.6	6.6	2.5	42.1	100	20.3
3	14.9	14.0	11.6	9.1	5.8	44.6	100	22.5
4	6.6	12.4	11.6	9.1	5.0	55.4	100	28.7
5	3.3	6.6	12.4	5.0	13.2	59.5	100	32.3
Entry	12.4	16.6	19.3	25.2	26.6		100	

b. Origin of firms observed in 2002

	Quintiles in 2002						US Exit Rate
Quintiles in 1996	**1**	**2**	**3**	**4**	**5**	**Exit**	
1	28.7	14.5	7.3	3.0	1.2	11.3	11.84
2	15.9	11.5	8.5	4.8	1.8	18.5	17.11
3	11.0	10.3	8.5	6.7	4.2	19.6	19.55
4	4.9	9.1	8.5	6.7	3.6	24.4	25.56
5	2.4	4.8	9.1	3.6	9.7	26.2	25.94
Entry	37.2	49.7	57.9	75.2	79.4		
Total	100	100	100	100	100	100	100

Note: Exit rates for US manufacturing are from Baily et al. (1992: 248, table A-3) and include both switching out and death rates.

58.7% of firms in the most productive quintile in 1996 managed to remain within the top 40% of the 2002 productivity distribution. Firms in the 2nd quintile in the 1996 productivity ranking behaved similarly; 21.5% upgraded to the top quintile in 2002 while 15.7% remained in the same position. Thus, 48% of firms in the top two quintiles in 1996 managed to stay put in the top 40% in 2002. Being relatively more efficient therefore increases not only the probability of surviving in the market but also the probability of remaining at the top of the productivity distribution. This result is consistent with the findings of most longitudinal studies and shows that relative efficiency, no matter what its source is, tends to persist. In Baily et al. (1992), 43.3% of US manufacturing firms in the 1st quintile maintained their position after five years. In total, 62% of US firms in the 1st quintile were still in the top 40% five years later, showing a higher degree of persistence than in Ethiopia.

A consistent but different story emerges when we look at the lower tail of the distribution. Looking at the exit column in table 3.3*a*, a remarkable 60% of the least efficient firms in 1996 exited the manufacturing sector before 2002. Similarly, 55% of firms in the 4th quintile faced the same fate, exiting the market. The table also shows that although exiting is not confined to inefficient firms, the exit rate declines substantially (albeit non-monotonically) as we go up the productivity ladder. Among the most productive firms, for instance, only a quarter had exited the market. This reveals the existence of a functioning market that exerts competitive selection; an observation that runs contrary to the claim that African markets tolerate inefficient firms. The last column of table 3.3*a* reports a similar pattern for US manufacturing, based on Baily et al. (1992): the share of exiting firms increases as one goes down the productivity distribution. The exit rate in Ethiopian manufacturing, however, is nearly twice as high as that in the United States in each quintile.[7]

Table 3.3*a* contains another important piece of information about entry. Nearly 500 firms joined the manufacturing sector between 1996 and 2002, of which 26.6% and 25.2% were in the bottom 5th and 4th quintiles in 2002, respectively. In other words, more than half of the entrants after 1996 were in the bottom 40% of the productivity distribution in 2002. This is consistent with the passive learning model presented in Jovanovic (1982), which assumes entrants to be relatively small and inefficient. For most entrants a process of learning precedes either upgrading in the productivity ladder or exiting the market. The other side of the story is that about 29% of entrants were among the top 40% of firms – 12.4% in the 1st and 16.6% in the 2nd quintile. It will be shown later that the latter is more of a size effect than a vintage effect.

Turning to the information contained in table 3.3*b*, the most efficient 20% of firms in 2002 originated in almost all of the quintiles, but most, i.e. about 29%, were in the top quintile in 1996. A decreasing proportion of firms originated in the lower quintiles; for instance, firms that were in the bottom quintile in 1996 accounted for only 2.4% of the firms in the 1st quintile in 2002. On the other hand, firms in the top two quintiles in 1996 accounted for less than two percent of the 5th quintile in 2002. This shows once again that relative efficiency not only increases the probability of survival but also the probability of remaining at or moving toward higher ranks of productivity.

It is interesting to note that although entrants accounted for a large proportion of every quintile in 2002, they were overly represented in the bottom two quintiles. Entrants accounted for 75% and 79% of the 4th and 5th quintiles, respectively, in 2002. Combining this fact with the observation from table 3.3*a* where exit is ubiquitous at the lower end of the productivity distribution, it becomes obvious that most exiting firms are new entrants. A positive correlation between entry and exit rates has been observed in a number of studies on developed country manufacturing (Geroski 1995), and the same seems to hold true for African manufacturing. The exit column in table 3.3*b* also shows that the proportion of exiting firms varies inversely with the productivity ranking. Only 11% of the exiting firms were from the top quintile in 1996 while the bottom two quintiles together accounted for 50% of the exiters. A comparison of exit rates with those in US manufacturing shows striking similarity. In both countries about 30% of the exiting firms were from the top 40% of firms while 50% of the firms exiting the market came from the bottom two quintiles in the initial measurement period.

The data also reveal that across the productivity distribution in 2002, firms that stayed in the top quintile between 1996 and 2002 exhibit above average productivity for the top quintile in 2002. Thus, firms that remained in the top quintile throughout the study period tended to be among the most productive, even within the top 20%. This is not the case for the remaining four quintiles, where the quintile average is equal to the average productivity of firms from all origins in 1996. The only exception is firms that slipped to lower ranks from the top quintile in 1996. These remained slightly above the average productivity of the relevant quintile, revealing once again that relative efficiency may erode, but it does so slowly, as pointed out by Hopenhayen (1992).

While the results discussed above are consistent with the findings of firm-level longitudinal studies from developed and developing countries, the magnitude of turnover appears to be very high in Ethiopia (table 3.3*a*). Employment-weighted dynamics changes the magnitude but leaves the pattern intact. The only exception is the story on entrants which will be discussed later. As table 3.3*c* shows, an employment-weighted 34% of firms in the bottom quintile in 1996 exited the market before 2002, which is nearly five times higher than the rate of exit from the top quintile (7.4%). On the other hand, the tenacity of relative efficiency seems to be magnified when transition is weighted by employment. Compared to table 3.3*a*, table 3.3*c* shows that about 46% of firms in the top quintile in 1996 remained in the same quintile six years later, while a weighted 32% moved down to the second quintile. The increase in the degree of persistence at the top of the distribution and the attenuation in exit rates when transition is weighted by employment show that employment is concentrated in the most productive firms. It also shows that exiting firms are relatively small in size, a fact that will be explored further in Chapter 4. Employment-weighted exit rates in Ethiopia are also more comparable with the exit rates in US manufacturing, although they are still on the higher side.

Table 3.3c: Transition of Firms Based on Employment Weighted Productivity Index: Destination of Firms Observed in 1996

	Quintiles in 2002							US Exit Rate
Quintiles in 1996	**1**	**2**	**3**	**4**	**5**	**Exit**	**Total**	
1	46.1	31.9	10.0	1.9	2.7	7.4	100	6.27
2	51.0	33.5	2.3	6.2	0.3	6.7	100	8.20
3	9.5	23.9	47.9	6.9	2.6	9.1	100	8.73
4	8.5	14.4	39.3	10.5	8.9	18.5	100	12.27
5	1.7	4.7	29.3	14.7	15.4	34.2	100	11.23
Entry	34.6	15.0	18.3	14.8	17.3		100	

Source: Author's computations based on CSA Manufacturing Census.
Note: Exit rates for US manufacturing are from Baily et al.(1992) and include both switching out and death.

Table 3.3*c* differs from table 3.3*a* in one important aspect, i.e., the distribution of entrants. Unlike table 3.3*a* where 50% of entrants are in the bottom two quintiles, employment-weighted entrants seem to be highly represented in the top two quintiles. A weighted 35% and 15% of entrants appear in the first and second quintile in the 2002 productivity ranking. This reveals that most entrants are small firms located at the lower tail of the productivity distribution and accounting for a relatively small fraction of manufacturing employment. It also shows that the handful of entrants among the top-ranking incumbents are relatively large in size. This indicates that size and productivity are closely related and the vintage effect that would have put most entrants at the top of the productivity distribution is simply not evident. Given that most employment is concentrated among the most productive firms which tend to maintain their relative efficiency, the high (unweighted) producer turnover rates in tables 3.3*a* and 3.3*b* do not imply high employee turnover.

Notwithstanding the interesting similarities in exit patterns with US manufacturing, the industry dynamics revealed in this chapter differ in key respects from the results in Baily et al. (1992).[8] For instance, the relationship between a firm's current and future relative productivity seems to be stronger in US manufacturing than in Ethiopia. This is shown by the relatively higher degree of persistence in the top quintile for US manufacturing (by nearly 5 percentage points) compared to Ethiopia. Another side of this difference is that the probability of exit amongst highly efficient firms in Ethiopia is nearly twice as high as that in the United States. The high producer turnover in Ethiopia is similar to findings for semi-industrialised countries of Latin America, where turnover rates are higher than those in established market economies like Canada and the United States. One reason for this difference in the rate of turnover is the composition of manufacturing in developing countries, which is predominately low-technology consumer goods industries requiring relatively small start-up capital. In this situation, exit may not be too costly for troubled firms. Financial constraints as well as political and macroeconomic instability in most developing countries may also induce firms not to enter with large production capacity (Tybout 2000).

Most importantly, upgrading from the lowest quintile to the top two quintiles is more likely to happen in US manufacturing than in Ethiopia. In the latter, only 10% of the least efficient firms managed to upgrade to the top two quintiles, compared to the 20% for the United States, as reported in Baily et al. (1992). Since small firms (most of them new entrants) account for a large fraction of the bottom two quintiles, this comparison suggests that the prospect of small firm survival and growth is lower in sub-Saharan Africa than in advanced economies. Such differences in post-entry performance reflect wide differences in the business environment in the two countries. In fact, for the least efficient firms in Ethiopia, exit is the most likely scenario, being some 60%, which is nearly twice as high as that in the United States. About one-third of firms in the least efficient quintile in the United States were still in the bottom two quintiles five years later, compared to only 13% in Ethiopia.

Baily et al.(1992) also found that new entrants in US manufacturing account for less than one-third of the population of firms in each quintile, except for in the least efficient quintile where they make up 38%. This is very different from the Ethiopian case, where more than 75% of firms in the bottom two quintiles are new entrants (table 3.3*b*). This is perhaps one of the reasons why Bailey et al. (1992) found no significant contribution of net entry to overall productivity growth in the United States, because entrants are not only small in size but also relatively fewer in number compared to developing countries. The nature of entry in Ethiopian manufacturing is comparable to that in Taiwan, where entrants played an important role for industrial growth during the 1970s and 1980s (Aw et al. 2001).

3.4.1 Selection and international competition

This section compares transition matrices among groups of industries exposed, to various degrees, to international competition. This sheds light on the selection process by showing whether competition from imports strengthens market forces. Two groups of industries are identified for this purpose: those with import penetration rates below 50% and those above the 50% threshold.[9] Industries with relatively low international competition, i.e. less than the 50% import penetration rate, include food and beverages, leather and footwear and non-metal industries. Industries with high international competition include textile and garments, chemical and plastics, metal, light-machinery, printing and paper, and wood and furniture.

In both high and low import-competition industries, the basic features of market selection observed earlier still apply: the probability of exit decreases as the productivity ranking of firms increases, and there is a considerable degree of persistence at the top of the productivity distribution. Tables 3.4 and 3.5, however, provide the extra insight that exit rates among inefficient firms are significantly higher in industries facing high competition from imports than in industries where import competition is relatively low. In the 4th quintile, for instance, the

Table 3.4: High-competition industries, transition of firms by unweighted productivity index in 1996 and 2002

	Quintiles in 2002						
Quintiles in 1996	**1**	**2**	**3**	**4**	**5**	**Exit**	**Total**
1	43.75	20.31	14.06	4.69	1.56	15.63	100
2	18.46	16.92	10.77	7.69	3.08	43.08	100
3	15.63	14.06	14.06	6.25	6.25	43.75	100
4	4.62	15.38	6.15	9.23	4.62	60.00	100
5	4.62	6.15	9.23	3.08	15.38	61.54	100
Entry	12.18	15.87	20.30	25.83	25.83		100

Source: Author's computations based on CSA manufacturing census.
Note: The transition matrix corresponds to table 3.3*a*.

Table 3.5: Low-competition industries, transition of firms by unweighted productivity index in 1996 and 2002

	Quintiles in 2002						
Quintiles in 1996	**1**	**2**	**3**	**4**	**5**	**Exit**	**Total**
1	37.50	12.50	7.14	5.36	1.79	35.71	100
2	16.07	17.86	14.29	7.14	1.79	42.86	100
3	16.07	10.71	10.71	7.14	8.93	46.43	100
4	8.93	14.29	10.71	10.71	5.36	50.00	100
5	5.26	7.02	12.28	7.02	12.28	56.14	100
Entry	12.16	18.02	19.37	24.32	26.13		100

Source: Author's computations based on CSA manufacturing census.
Note: The transition matrix corresponds to table 3.3*a*.

exit rate is 60% for industries with high import competition and 50% for those with low competition from imports. In the 5th quintile, the exit rate is 61.5% for industries with high import competition and 56% for those with lower competitive pressure.[10] However, the exit rate in the top quintile is 15.6% for high-competition industries, which is less than half of the corresponding rate for industries with low import competition, i.e., 35.7%. Exposure to international competition therefore tends to reduce the market's tolerance of inefficient producers while increasing the probability of survival for productive firms.[11] Trade liberalisation, therefore, seems to have a positive role in as long as turnover promotes industry-level productivity growth.

Employment-weighted transition matrices (not reported here) indicate that employment is concentrated among efficient firms in both groups of industries. However, persistence at the top of the distribution is higher among industries with relatively less international competition. This indicates that part of the efficiency gain in industries with more exposure to international competition may involve downsizing, which reduces the degree of concentration of employment at the top of the distribution relative to protected industries (Baily, Bartelsman and Haltiwnger 1996). The employment-weighted exit rates are much lower than the unweighted exit rates in both groups of industries, showing that exiting firms are predominantly small in size. However, the link between smallness and inefficiency appears to be stronger in industries with high import penetration, as the employment-weighted exit rates are lower in this group of industries.

3.5 Turnover and industry dynamics

Section 3.4 showed that industries are comprised of heterogeneous firms and that the processes of entry, survival and exit reflect underlying differences in relative efficiency. This section addresses the question of how important these processes have been for aggregate (industry) productivity. It does this with a decomposition analysis of aggregate productivity growth.

3.5.1 Decomposition methods

The growth accounting, or representative firm, approach pays utmost attention to intra-firm productivity growth as the sole source of aggregate productivity growth. Research based on micro-data reveals that firm entry and exit as well as reallocation of inputs and market share from less productive to more productive incumbents could also play an important role. Extant evidence is mixed, however, in the sense that reallocation does not always play a positive role in aggregate productivity, and in those cases where it does, the magnitude differs widely across industries and time. Two decomposition methods are discussed below, after which new evidence is introduced from Ethiopian manufacturing.

In the growth accounting literature, TFP is computed as the difference between the growth in output net the contribution of input growth. Until recently TFP computation has been based on industry-level data. This method forces researchers to assume that all firms have the same level of technology and that productivity growth is a smooth shift in industry-wide technology. With increased availability of micro-data one need not make these assumptions.

As shown in equation (17), firm-level TFP is calculated as follows:

$$\ln TFP_{it} = y_{it} - \beta' x_{it} \tag{18}$$

where TFP_{it} is the productivity of firm i in period t, y_{it} is the logarithm of the value-added, x_{it} is a vector of inputs in logarithms and β is a vector of factor elasticities. Industry-level aggregate TFP is simply a weighted sum of establishment-level TFP derived from the value-added production function outlined in section 3.3. Firms' shares in industry-level value-added are used as weights to estimate industry-level productivity. Industry-level productivity growth between two periods is calculated in accordance with the Baily, Hulten and Campbell (1992) method (BHC for short), or some variant of it:

$$\Delta \ln TFP_t = \sum_i s_{it} \ln TFP_{it} - \sum_i s_{i,t-1} \ln TFP_{i,t-1} \tag{19}$$

where s_{it} represents establishment i's share in industry-level value-added in period t.

Growth in aggregate productivity can then be decomposed into four components: intra-firm productivity growth with fixed shares, reallocation of market shares, a covariance term and net entry. The decomposition method used here follows the BHC approach as modified in Haltiwanger (1997) for an unbalanced panel.

$$\begin{aligned}
&\sum_i s_{it} \ln TFP_{it} - \sum_i s_{i,t-1} \ln TFP_{i,t-1} = \\
&\left[\sum_{i\in c} s_{i,t-1} \Delta \ln TFP_{it} + \sum_{i\in c} \left(\ln TFP_{i,t-1} - \ln TFP_{t-1}\right)\Delta s_{it} + \sum_{i\in c} s_{it} \Delta \ln TFP_{it}\right] + \\
&\left[\sum_{i\in N} s_{it}\left(\ln TFP_{it} - \ln TFP_{t-1}\right) - \sum_{i\in D} s_{i,t-1}\left(\ln TFP_{i,t-1} - \ln TFP_{t-1}\right)\right]
\end{aligned} \tag{20}$$

The first block of terms in the right-hand side of equation (20) represents the contribution of continuing firms (represented by subscript *C*) to aggregate productivity growth, which is decomposed further into three sub-components: (i) the first term is the change in productivity weighted by initial market share- referred to as the "within-effect", (ii) the second term is the change in market share weighted by the deviation of initial firm-level productivity from the initial industry mean- referred to as the "between-effect", and (iii) the third item is a covariance term that combines changes in both productivity and market share. Most empirical applications lump the covariance term with the share effect to avoid ambiguity. The share (between or reallocation) effect is a measure of industry rationalisation whereby market shares are continuously reshuffled in favour of efficient firms. The second block of terms, terms four and five, represent net entry, which is the share-weighted effect of entrants (represented by subscript *N*) after deducting the role of exiting firms (represented by subscript *D*). These last two terms are expressed as the share-weighted deviations from the industry mean in the base year. While following the BHC method, the productivity terms in this chapter are indexed to the industry mean in the base year. For a decomposition analysis based on an unbalanced panel, the use of such deviations from the industry mean implies that entry (exit) contributes to industry-level productivity growth if the efficiency of entrants (exiting firms) is above (below) the mean industry practice in the base year (Haltiwanger 1997). Notice that it is industry rationalisation (the "between effect") and net entry (producer turnover) that constitute the role of market selection for aggregate productivity growth. The intra-firm ("within effect") on the other hand corresponds to productivity growth in the representative firm approach.

Petrin and Levinson (2004) provided another decomposition method based on change in the growth rate rather than change in the level of productivity. They brought together two guiding principles for aggregating plant-level productivity in the growth accounting approach to use as a benchmark for assessing the validity of aggregation/decomposition exercises. The first guiding principle was put forward by Domar (1961) and underscores that aggregating and disaggregating the economy over different industries, outputs and over time should be possible without affecting the magnitude of the residual. This means that computation of productivity based on one method should be able to predict productivity patterns based on another. The second guiding principle states that productivity growth should measure the impact on final demand of changes in plant-level factor efficiency (Hulten 1978). This second principle is key when considering manufacturing activities in which part of an establishment's output is used by others as an input. In this situation an increase in plant-level efficiency leads to an increase in aggregate demand, both directly through more final output as well as indirectly through the increased availability of inputs for use by other plants. The implication of this analysis is that when the plant-level productivity index is derived from a production function based on total output, the appropriate weight for aggregating the industry-level productivity index should be the ratio of plant-level output to industry value-added (Petrin and Levinson 2004). $\Delta w = \sum \alpha_i \Delta w_i$ where $\alpha_i = \frac{q_i}{\sum v_i}$ q_i is total output and v_i is value-added.

In this setting Δw represents industry productivity growth in the growth accounting approach and it measures the rate of change of the social production possibility frontier, holding primary inputs constant (Petrin and Levinson 2004: 6). It is also possible to calculate the firm-level productivity index from a value-added production function. In the latter case, the firm's share in industry-level value-added should be used as weight. Hulten (1978) refers to the growth in the industry productivity index calculated from a value-added production function as the effective rate of productivity growth. The reason is that in the value-added context, growth in aggregate productivity measures the cumulative impact of plant-level technical efficiency on final demand (output).

If output growth in firm i is represented by dy_i, its total differential can be written as follows:

$$dy_i = \beta l_i dl_i + \beta k_i dk_i + \beta m_i dm_i + du_i \qquad (21)$$

where β_j denotes the elasticity of output with respect to input j, dj_i represents growth in input j (i.e., capital k, labour l or intermediate inputs m), and du_i is Hick's neutral technological change. Using Hulten's (1978) insight on the second rule of aggregation, growth in value-added can be computed as follows:

$$dv_i = \frac{dy_i - \beta m_i dm_i}{1 - \beta m_i} = \frac{\beta l_i dl_i + \beta k_i dk_i + du_i}{1 - \beta m_i} \qquad (22)$$

In this equation the value-added growth is obtained by deducting the contribution of intermediate inputs to total output growth and raising the difference by a multiplier equal to $\frac{1}{1-\beta m_i}$. The latter accounts for the role of plant-level technical efficiency through increased availability of intermediate inputs. The aggregation to industry-level growth rate of value-added is given by $\sum s_{vi} dv_i$ where s_{vi} is a plant's share in industry value-added. Accordingly, the effective rate of productivity growth can be calculated by deducting the role of primary inputs from the growth rate of value-added:

$$dTFP_i = dv_i - \frac{\beta l_i dl_i + \beta k_i dk_i + du_i}{1 - \beta m_i} = \frac{du_i}{1 - \beta m_i} \qquad (23)$$

The growth accounting approach therefore suggests that aggregate productivity growth should be obtained as the difference between the rate of growth of industry output and aggregate primary inputs where value-added shares are used as weights.

$$dTFP = \sum s_{vi} dTFP_i = \sum s_{vi} dv_i - \sum s_{vi}\left(\frac{\beta l_i dl_i + \beta k_i dk_i}{1-\beta m_i}\right) = \sum s_{vi} \frac{du_i}{1-\beta m_i} \qquad (24)$$

It is interesting to note that unlike the approach of Baily et al. (1992), the growth accounting procedure leaves no room for reallocation of inputs as a source of aggregate productivity growth. This is because of the way the effective rate of productivity growth is computed at the firm level and not as such a denial of the fact that resources are reallocated in response to productivity shocks. However, Petrin and Levinsohn (2004) proposed and tested an alternative approach in which a reallocation effect can be separately identified. In their method, the focus is on changes in the growth rate of productivity instead of growth in the level of productivity. A reallocation effect is then realised as resources are shifted toward firms with a relatively higher rate of productivity growth.

The decomposition of change in productivity growth in the Petrin-Levinsohn approach requires data on three successive periods and is given as follows:

$$\sum \frac{s_{vi,t+2} + s_{vi,t+1}}{2}\left(\ln TFP_{i,t+2} - \ln TFP_{i,t+1}\right) - \sum \frac{s_{vi,t+1} + s_{vit}}{2}\left(\ln TFP_{i,t+1} - \ln TFP_{it}\right) \qquad (25)$$

Like Baily et al. (1992), Petrin and Levinsohn identify continuing firms (*C*) , entrants (*N*) and exiters (*D*) for the decomposition. They also identify three sources of productivity growth: intra-firm productivity growth, the reallocation effect and net entry, with no covariance term, which is a source of confusion in the BHC method. The productivity and reallocation effects are computed only for continuing firms that exist in periods *t, t+1* and *t+2*. For firms that exist only in *t* and *t+1* (exiters) and in period *t+1* and *t+2* (entrants) their contribution to overall productivity growth is captured through net entry.

The intra-firm productivity term is represented as follows:

$$\sum_{i\in c} \frac{s_{vi,t+2} + 2 * s_{vi,t+1} + s_{vit}}{4} * \left(\ln \frac{TFP_{i,t+2}}{TFP_{i,t+1}} - \ln \frac{TFP_{i,t+1}}{TFP_{it}}\right) \qquad (26)$$

For incumbent firms, part of their contribution to the change in productivity growth is the summation of the difference in their productivity growth weighted by the average value-added share for the three periods, with the share in *t+1* taken twice.

The reallocation effect is captured as follows:

$$\sum_{i\in c} \frac{1}{2} * \left(\ln \frac{TFP_{i,t+2}}{TFP_{i,t+1}} + \ln \frac{TFP_{i,t+1}}{TFP_{it}}\right) * \left(\frac{s_{vi,t+2} - s_{vit}}{2}\right) \qquad (27)$$

These terms thus represent the change in value-added share weighted by the average rate of productivity growth between periods **t** to *t+1* and *t+1* to *t+2.*

The third term is net entry. Unlike the BHC approach, the role of net entry for change in rate of growth of aggregate productivity requires both exiting firms and entrants to be observed for two successive periods. This means that firms entering in the current period ($t+2$) and exiting firms that exited in period t are not included in this estimation. Net entry is calculated as follows:

$$\sum_{i\in N}\frac{s_{vi,t+2}+s_{vi,t+1}}{2}*\left(\ln\frac{TFP_{i,t+2}}{TFP_{i,t+1}}\right)-\sum_{i\in D}\left(\frac{s_{vi,t+2}+s_{vi,t+1}}{2}\right)\left(\ln\frac{TFP_{i,t+1}}{TFP_{it}}\right) \quad (28)$$

According Petrin and Levinsohn's method, if inputs are not reallocated away from firms with low productivity growth, aggregate productivity growth will change only through the effect of share weighted change in intra-firm productivity assuming no entry and exit. On the other hand, if the productivity effect is zero, growth rate of aggregate productivity may change due to reallocation of market share to firms with higher growth rate of productivity. Firm exit will be a drag on productivity growth if there are no entrants or if share-weighted productivity growth among entrants is slower than that of exiters.

3.5.2 Results of productivity decomposition analysis

This section discusses the results of decomposing industry-level productivity growth in Ethiopian manufacturing based on the BHC (1992) and the PL (2004) methods. We compare how well they predict the aggregate productivity growth estimated independently at the industry-level using the Divisia index in line with the growth accounting method. The purpose is to identify the role of heterogeneity and turnover in aggregate productivity growth while discriminating among methods of decomposition in as far as the data allows.

The analysis was carried out for nine industries. Table 3.6 presents the decomposition of productivity growth based on the BHC method. Unlike other studies, value-added shares are used as weights for aggregating firm-level productivity. However, the results are essentially the same if output shares are used. This is largely due to the fact that inter-industry relations in terms of input use is rather limited in Ethiopian manufacturing. Table 3.7 presents the decomposition of changes in the rate of productivity growth according to the PL method. Both tables are compared with the industry productivity growth based on the representative firm approximation in a competitive market where factor shares in revenue represent factor elasticities. The tables also provide an analysis at the manufacturing sector level whereby industries are aggregated using their average share in sector-wide value-added over the study period.

Columns 2 and 3 in table 3.6 report, respectively, productivity growth based on the Tornquist method applied to the Divisia index and the BHC method for an industry. The two series are highly correlated, capturing the same trend. The decomposition of productivity growth at the manufacturing sector level is reported at the end of table 3.6. The most important and clear observation emerging from this exercise, particularly when regarded at the manufacturing sector level, is that productivity has been declining in Ethiopian manufacturing with little inter-in-

Table 3.6: Decomposition of industry productivity growth: The Baily-Hulten-Campbell method

		Industry Productivity Growth		Within Effect	Reallocation Effect	Net Entry
		Tornquist Index	BHC Aggregate			
1		2	3	4	5	6
Food & Beverage	1997	-15.52	-7.07	-15.46	7.74	0.65
	1998	-1.21	-0.54	-9.92	4.84	4.54
	1999	-1.08	-11.71	-6.53	-25.17	19.99
	2000	-27.30	-4.97	-48.54	50.33	-6.76
	2001	25.17	4.94	-1.41	-3.26	9.61
	2002	-13.75	-9.89	-12.65	2.51	0.26
Textile & Garments	1997	-10.10	-23.47	-18.34	1.29	-6.42
	1998	17.30	10.22	-29.59	39.97	-0.11
	1999	50.44	42.10	17.14	24.87	0.09
	2000	15.63	14.59	-21.36	22.84	13.11
	2001	-38.17	-41.09	-56.81	9.09	6.63
	2002	-1.38	-13.29	-44.62	31.08	0.25
Leather & Footwear	1997	31.80	-5.73	-22.54	-17.86	34.66
	1998	-44.52	-97.38	-127.07	29.65	0.04
	1999	59.80	148.45	-1.14	144.59	5.00
	2000	-84.75	-157.67	-105.39	46.55	-98.83
	2001	-58.12	-29.87	-119.14	31.38	57.89
	2002	-0.09	-37.20	-73.99	36.98	-0.19
Wood & Furniture	1997	17.24	5.30	-7.99	26.50	-13.20
	1998	17.26	23.36	2.78	9.96	10.61
	1999	-44.00	-25.46	-68.93	42.56	0.91
	2000	-5.26	5.36	-14.87	23.22	-2.98
	2001	4.97	3.08	-5.43	12.35	-3.84
	2002	-27.76	-19.23	-37.12	25.01	-7.12
Printing & Paper	1997	-13.75	-1.30	-2.56	27.66	-26.37
	1998	15.34	-3.50	14.86	-28.61	10.25
	1999	11.45	-1.32	-5.92	5.07	-0.47
	2000	-56.68	-26.75	-61.48	32.12	2.61
	2001	39.04	52.08	28.05	26.48	-2.45
	2002	-19.63	-53.17	-50.37	-2.48	-0.33
Chemical & Plastic	1997	2.74	2.00	-43.21	24.95	20.25
	1998	5.48	12.96	-60.06	15.28	57.74
	1999	-30.33	-26.16	-55.57	22.50	6.92
	2000	55.18	77.63	33.80	43.24	0.60
	2001	-37.96	-57.53	-54.79	-2.63	-0.11
	2002	-7.18	12.48	-12.97	20.82	4.63

Source: Author’s computations based on CSA manufacturing census.

dustry differences. Manufacturing sector productivity declined by about 5% per annum based on the Divisia Index and by about 4.9% per annum according to the BHC method. It is hard to find industries with steady productivity growth, except the textile and light machinery industries, in which productivity grew three

Table 3.6: Continued

		Industry Productivity Growth		Within Effect	Reallocation Effect	Net Entry
		Tornquist Index	BHC Aggregate			
1		2	3	4	5	6
Non-Metal	1997	8.11	13.62	-7.48	20.63	0.48
	1998	-44.46	-4.10	-82.88	79.92	-1.14
	1999	15.96	26.52	37.45	24.20	-35.14
	2000	-24.15	-20.99	-40.16	20.23	-1.06
	2001	-36.60	-32.33	-30.93	3.47	-4.87
	2002	22.77	20.25	14.67	6.02	-0.43
Metal	1997	-19.46	-2.21	-5.08	-6.22	9.09
	1998	-76.43	-82.76	-108.78	15.95	10.07
	1999	-7.46	-39.18	-74.13	34.94	0.01
	2000	35.22	39.54	21.25	16.66	1.62
	2001	-28.87	-20.35	-48.89	2.92	25.62
	2002	-9.55	31.56	-30.45	37.43	24.58
Light Machinery	1997	-31.61	-0.28	-52.20	56.37	-4.46
	1998	29.18	50.18	6.77	39.34	4.07
	1999	22.95	-10.57	15.40	-26.76	0.79
	2000	6.25	-4.52	-0.03	-30.99	26.49
	2001	-18.42	-19.24	-18.71	-1.33	0.38
	2002	15.66	12.53	8.57	19.74	-15.77
Manufacturing	1997	-8.36	-5.03	-17.45	10.05	2.36
	1998	-6.88	-7.42	-32.77	15.01	10.35
	1999	4.21	0.96	-12.41	4.58	8.79
	2000	-13.26	-0.73	-33.65	39.61	-6.68
	2001	-0.21	-9.94	-22.33	2.87	9.52
	2002	-8.77	-6.91	-20.86	12.11	1.84
Period Average		-5.55	-4.85	-23.25	14.04	4.36

Source: Author's computations based on CSA manufacturing census.

years in a row during 1998-2000. It also appears that productivity losses within firms have been the major source of negative aggregate productivity growth. This result is consistent with the findings of decomposition analysis for developed and developing countries where the intra-firm productivity growth/decline determines the path of productivity at the industry level (Baily et al. 1992; Griliches and Regev,1995; Aw et al. 2001). According to Table 3.6, the within effect was negative for more that 80% of the (annual) observations on productivity growth, with all industries taken together.

On the other hand, reallocation of resources from less efficient to more productive incumbents did play a positive role with few exceptions. Although it was not sufficient to completely offset the secular decline in intra-firm productivity, market selection mitigated the decline in aggregate productivity by reallocating market share to more efficient firms. It is important to note that (the logarithm of) firm-level productivity was indexed to the representative firm in the initial year such that an increase in market share for a particular firm would contribute to industry productivity growth only if the firm was above the industry average in the base year. Similarly, a decline in market share could boost industry productivity if the firm's efficiency was below the mean industry practice in 1996. The critic of Petrin and Levinson on the BHC approach notwithstanding, table 3.6 shows that underlying productivity differences and the selection power of markets have played important role in industry evolution. If we look the manufacturing sector as a whole in table 3.6 (end of table), reallocation of resources managed to offset 60% of the decline in the level of productivity that would have occurred due to the intra-firm productivity decline. Although annual productivity growth at the level of individual industries tends to be volatile, the contribution of the reallocation effect is still evident in offsetting a potential 40% productivity decline in the food and metal industries, and more than 60% of the decline in other industries.

Table 3.6 also reveals net entry to be a source of productivity growth at the manufacturing sector level. The share-weighted productivity of entrants has been higher than that of exiters in these industries. The table also shows that producer turnover had a positive role in five out of nine industries during the study period. The industries in which net entry had a negative effect on productivity seem to be non-import competing industries such as wood and furniture, non-metal and printing and paper. In these sectors, the observed situation is more likely to be the result of the entry of less efficient firms. The leather and footwear industry also experienced a small but negative net entry effect, which is mainly due to exit of relatively productive firms from the market due to intense competition largely from Chinese imports. Nonetheless, except for a few years, the role of net entry has not been very large, suggesting that productivity of entrants was only marginally higher/lower than that of exiting firms. This also reaffirms that entry and exit take place at the bottom end of the productivity distribution, which is the locus of small firms with small market share.

The positive net entry effect in Ethiopian manufacturing is much higher than the findings of Baily et al. (1992) for the United States, where it played essentially no significant role. At 4.5 percentage points on average, the evidence from Ethiopia appears to be comparable to that of Taiwan in terms of percentage points. However, its overall contribution to industry-level productivity growth is far less than in Taiwan, where it accounted for nearly half of the productivity growth during 1981-1986 (Aw et al. 2001). The reason why net entry played such a huge role in Taiwan has to do with the large difference between the productivity of entrants and that of exiting firms, as well as the relatively large share of the entrants in total output. Net entry did not play a significant role in US manufacturing, for the exact opposite reasons. The Ethiopian case appears to be somewhere in between with entrants and exiting firms showing very little difference in productivity but with entrants as a group accounting for a substantially larger market share. Firms exiting the market in the five years leading up to 2002 accounted for about 8% of the market share in 1996 while firms that joined

Table 3.7: Decomposition of change in productivity growth: The Petrin-Levinsohn method

		Productivity Growth – Tornquist Index	Change in Productivity Growth	Within Effect	Reallocation Effect	Net Entry
1		2	3	4	5	6
Food & Beverage	1997	-15.52				
	1998	-1.21	14.3	4.3	4.8	0.2
	1999	-1.08	0.1	-1.3	2.1	-1.2
	2000	-27.30	-26.2	-7.9	3.2	-22.0
	2001	25.17	52.5	57.1	3.9	0.5
	2002	-13.75	-38.9	-59.8	17.8	0.6
Textile & Garments	1997	-10.10				
	1998	17.30	27.4	-25.5	11.7	-0.1
	1999	50.44	33.1	19.7	32.7	0.0
	2000	15.63	-34.8	-71.0	16.7	4.1
	2001	-38.17	-53.8	-39.6	8.4	-8.3
	2002	-1.38	36.8	3.5	30.4	0.0
Leather & Footwear	1997	31.80				
	1998	-44.52	-76.3	-72.1	1.4	-29.7
	1999	59.80	104.3	68.0	89.7	2.3
	2000	-84.75	-144.6	-188.6	27.6	-30.4
	2001	-58.12	26.6	-1.1	35.4	-1.2
	2002	-0.09	58.0	50.5	12.8	-28.5
Wood & Furniture	1997	17.24				
	1998	17.26	0.0	-14.8	9.5	-1.0
	1999	-44.00	-61.3	-72.8	11.7	-3.7
	2000	-5.26	38.7	46.8	7.2	2.8
	2001	4.97	10.2	-2.8	8.6	2.0
	2002	-27.76	-32.7	-35.9	9.2	0.6
Printing & Paper	1997	-13.75				
	1998	15.34	29.1	10.5	2.3	1.9
	1999	11.45	-3.9	-24.7	5.2	13.0
	2000	-56.68	-68.1	-61.5	2.2	0.8
	2001	39.04	95.7	80.5	14.9	0.4
	2002	-19.63	-58.7	-70.5	5.0	-0.6
Chemical & Plastic	1997	2.74				
	1998	5.48	2.7	-41.7	18.6	-5.7
	1999	-30.33	-35.8	17.2	7.1	-22.0
	2000	55.18	85.5	53.8	24.7	1.0
	2001	-37.96	-93.1	-102.8	12.6	-0.4
	2002	-7.18	30.8	18.4	17.5	0.1

Source: Author's computations based on CSA manufacturing census.

manufacturing after 1997 accounted for more than a quarter of industrial output in 2002. The latter has little to do with entrants being significantly larger than exiters – the median entrant has 18 employees while the median exiter has 16 employees. However, Ethiopian manufacturing is dominated by new entrants that are not significantly more efficient or larger than the exiting firms but which collectively account for a significant share of manufactured output. This is

Table 3.7: Continued

		Productivity Growth – Tornquist Index	Change in Productivity Growth	Within Effect	Reallocation Effect	Net Entry
1		2	3	4	5	6
Non-Metal	1997	8.11				
	1998	-44.46	-52.6	-82.2	23.7	3.6
	1999	15.96	60.4	58.7	9.1	3.8
	2000	-24.15	-40.1	-60.6	19.0	-1.7
	2001	-36.60	-12.5	-24.7	15.6	-0.2
	2002	22.77	59.4	52.7	3.0	-0.7
Metal	1997	-19.46				
	1998	-76.43	-57.0	-85.1	14.3	3.5
	1999	-7.46	69.0	-9.9	39.3	-3.3
	2000	35.22	42.7	68.2	9.1	0.5
	2001	-28.87	-64.1	-77.7	14.1	-0.4
	2002	-9.55	19.3	15.6	5.1	-1.4
Light Machinery	1997	-31.61				
	1998	29.18	60.8	64.0	4.4	-3.4
	1999	22.95	-6.2	-22.9	9.2	2.9
	2000	6.25	-16.7	11.6	3.9	-3.3
	2001	-18.42	-24.7	-49.8	11.5	-6.3
	2002	15.66	34.1	35.5	0.8	-3.6
Manufacturing	1997	-8.36454				
	1998	-6.87591	-11.60	-18.81	8.71	-1.51
	1999	4.208171	17.39	6.15	13.47	-2.23
	2000	-13.2598	-18.73	-16.21	9.69	-12.20
	2001	-0.21183	19.53	10.96	9.28	-0.70
	2002	-8.76766	-11.24	-25.57	15.67	-1.34

Source: Author's computations based on CSA manufacturing census.

consistent with the results in table 3.3b, which shows entrants accounting for between one-third and three-quarters of all firms in each quintile in 2002.

Table 3.7 shows the Petrin-Levinsohn aggregation of firm-level changes in productivity growth, which closely captures the movements in the industry productivity index according to the growth accounting approach. In most cases it picks the exact level of change, despite the fact that it does not include firms which exited in time *t* and firms that joined an industry in *t+2*. Although productivity growth was negative during the study period for most industries, column 4 in table 3.7 shows a rather cyclical change in the rate of productivity growth. If productivity keeps declining but at a decreasing rate in column 2, this phenomena shows up as a positive outcome in column 3, accounting for some of the cyclical trend in the Petrin-Levinsohn index. Productivity in the food industry was declining, for instance, at a decreasing rate between 1997 and 1999 according to the growth accounting measure in column 2; the Petrin-Levinsohn measure of change in productivity growth in column 3 captures this as an improvement.

The Petrin-Levinsohn decomposition is interesting in that it reaffirms a more or less secular decline in intra-firm productivity (column 4), and this has been the major source of productivity decline at the industry level. Like the BHC method, the reallocation effect is positive and significant. The difference compared to the BHC method is that the reallocation effect is positive for all industries and all time periods with no exceptions. In the BHC method, there were cases in which the reallocation effect was negative, which always coincided with a productivity decline at the industry level, showing a pro-cyclical tendency in this component. The Petrin-Levinsohn method shows that the reallocation effect is positive even during periods of productivity declines. The results of the Petrin-Levinsohn method suggest that reallocation always plays a positive role when resources are reallocated to firms with higher productivity growth and not just to firms with an above average productivity level. During periods of decline in the rate of manufacturing productivity growth, reallocation of market share offset 45% of the decline that would have occurred due to the decline in intra-firm productivity and to negative net-entry effects. On the other hand, reallocation contributed more than 60% of the increase in the rate of productivity growth during periods of improvement. In the food and beverage and chemical and plastic industries, for instance, reallocation more than offset the negative effect from the other two sources. In other industries it offset 60% to 90% of the potential decline in the rate of productivity growth.

The Petrin-Levinsohn method also reveals that net entry has been a drag on the rate of change of productivity growth. This appears at odds with the result from the BHC method (table 3.6). However it could well be that although entrants are relatively more productive than exiting firms, their productivity has not been growing relatively faster. It could also mean that new entrants suffered larger negative productivity shocks than exiting firms but their decision to exit is yet to come. Looking at the manufacturing sector as a whole we see that net entry tended to slow the rate of productivity growth for almost the entire study period. This negative effect on the rate of productivity growth was no more than 5 percentage points for most industries, except for the leather and footwear industry, where it exerted a net drag of more than 15 percentage points.

The positive role played by producer turnover and the reallocation of market shares toward more efficient firms shows markets as functioning well and contributing to productivity growth. However, these contributions have at best managed to mitigate the more pervasive intra-firm productivity decline which continues to drive a downward spiral in industry productivity. Unleashing market forces, therefore, cannot on its own guarantee that industries in developing countries will be on a long-term competitive path. Reshuffling of resources has its limits, as firms discover sooner or latter the competitive advantages of the most productive firms, as models of market selection indicate. Although a perfect imitation of best practices may not be possible due to intangible elements, the gap is expected to narrow over time leaving little room for improvement through reallocation (Petrin and Levinsohn 2004). A long-term development strategy will thus have to look beyond the disciplinary and allocative role of markets and explore factors that determine intra-firm technological capabilities.

3.6 Shifts in the distribution of productivity

In addition to tracing firm movements along the productivity distribution, as in section 3.4, census micro-data allows visualisation of trajectories in the population distribution of productivity over time. For instance, productivity growth in an industry will result in a rightward shift of the distribution, while a shift to the left indicates a productivity decline. Figure 3.5 compares kernel density functions of productivity in 1996 and 2002 for each industry. To formalise our analysis of shifts in distributions, a Kolmogorove-Smirnove test for the equality of distributions is provided in table 3.8.

The figures show that only two industries, namely, chemicals and plastic and metal, exhibit a significant positive shift in the distribution of firm-level productivity during the study period. It is important to note that the improvement in the chemical industry is largely the result of productivity growth among firms that were below the 1996 mean industry practice, rather than an increase in the proportion of highly efficient firms. This suggests that the productivity gains in this industry were driven by convergence to the frontier technology in the industry rather than a shift in that frontier. Such convergence indicates the effect of market competition on innovation, forcing inefficient firms to strive toward best practice. In the metal industry, the shift to the right occurred along the entire distribution and hence both convergence to and shifts in the frontier must have taken place. The results in table 3.8 indicate that the positive shifts in these two industries are significant at 5%. The employment-weighted distribution is essentially the same except that the shift in the chemical industry is significant only at the 10% level.

On the other hand, the distribution of productivity shifted to the left in the food and beverage and wood and furniture industries. The decline in the productivity of the food industry is mainly due to a fall in the proportion of firms at the top end of the distribution, while in the wood and furniture industry it is due to the entry of less efficient firms. It is important to note that the wood and furniture industry is among the least capital-intensive industries and has a fast-growing number of enterprises. Although there is high import penetration rate in this industry, competition from imports is more apparent than real. Imported furniture serves only the upper end of the market and does not pose significant threat to local firms. In fact, major furniture enterprises in the country are also importers of high-quality office and hospital furniture, showing that the two can go together in a profitable fashion.

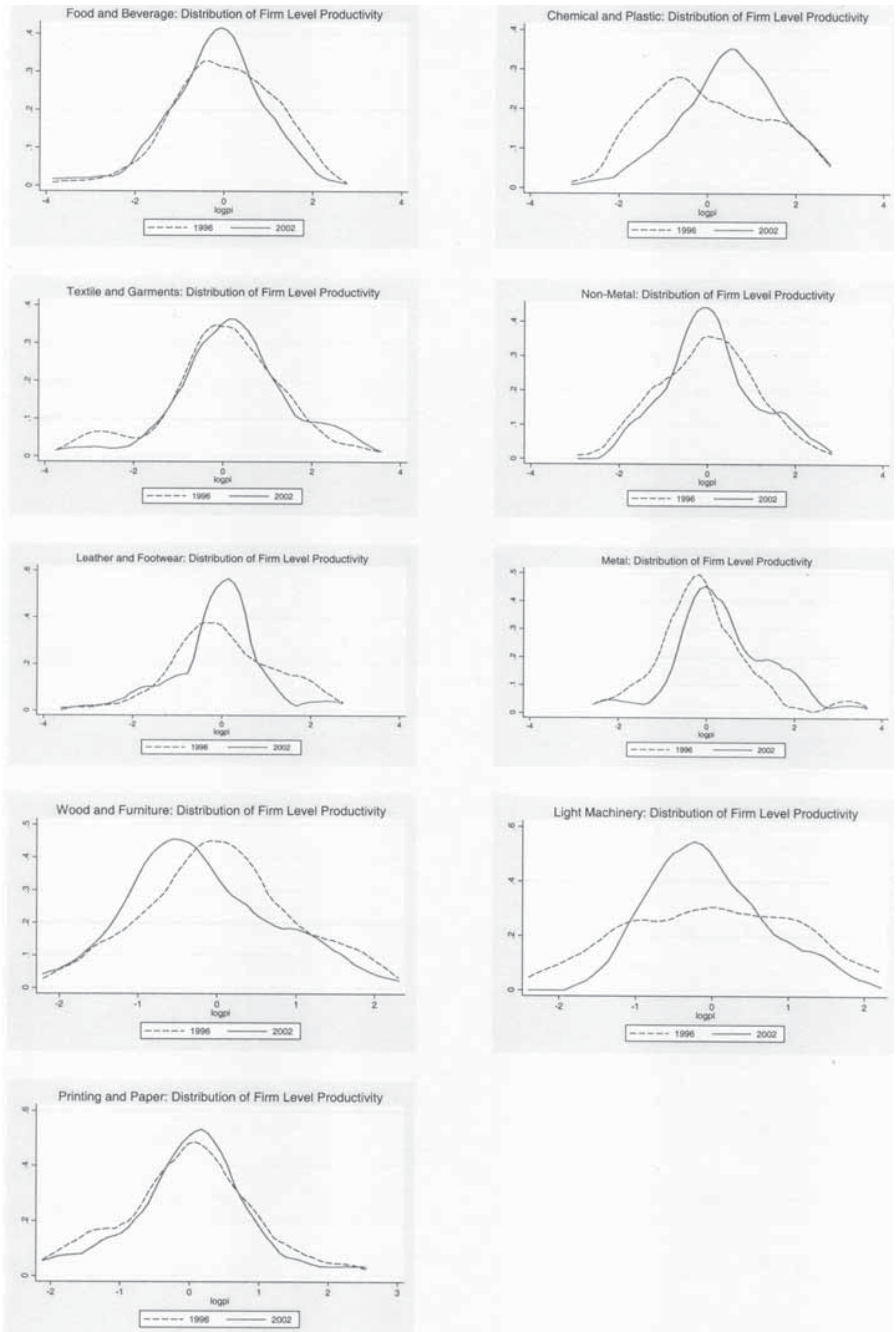


Figure 3.5: Shifts in the distribution of productivity, 1996 to 2002

Source: Author's computations based on CSA manufacturing census.

Table 3.8: Test of equality of productivity distributions in 1996 and 2002

	Kolmogorove-Smirnove Test			
	Unweighted		Weighted[a]	
	D	p-value	D	p-value
Food and Beverage	-0.123	0.059	-0.1595	0.009
Textile and Garments	0.109	0.465	0.0831	0.653
Leather and Footwear	0.198	0.114	0.211	0.097
Wood and Furniture	-0.214	0.004	-0.2385	0.001
Printing and Paper	0.087	0.667	-0.1167	0.511
Chemical and Plastic	0.247	0.023	0.2029	0.089
Non-Metal	0.097	0.513	-0.1348	0.276
Metal	0.284	0.013	0.2393	0.048
Machinery	-0.278	0.227	0.2102	0.441

Source: Author's computations based on CSA manufacturing census.
Notes: Negative values for *D* indicate that the 2002 level of productivity is lower than the 1996 level.
a: value-added share is used for weighting.

There is also a demand side story to this development. Greater emphasis on social services in the recent poverty-focused reform programmes has led to increased government spending on heath and education infrastructure. The growing demand seems to have generated a sufficient market, attracting even the least efficient entrants. Formal tests of distribution show that the shift to the left in these two industries is statistically significant. Weighting by market share makes the negative shift in the food industry significant at 1% showing the loss in productivity at the top end of the distribution to have been very important. This simply underlines the fact already indicated that firms at the top end of the productivity rank have large market shares. Although the average import penetration rate in the food industry is relatively low, data show that it has been on the increase, and some branches of the industry such as edible oil manufacturing complain about competition from food-aid related imports.

Although the shape of the distribution changed for the remaining five industries between 1996 and 2002, statistical tests show these as not significant. Productivity in these industries essentially remained unchanged, regardless of reshuffling at the firm level. In the leather and footwear and light-machinery industries, for instance, there was a convergence in productivity, revealed by the decline in the width of the distribution in 2002. This suggests that although there was no significant shift to the right in industry-level productivity, technological practices have tended to converge, which is also an impact of growing competition. In fact, for the leather and footwear industry, the market-share-weighted distribution shows a rightward shift that is significant at 10%. Taken together, this indicates that markets are exerting disciplinary influence on firms, provoking them to search for the best practice technology.

3.7 Conclusions

Efficient allocation of resources is a critical aspect of industrial competitiveness. Using different techniques, this chapter investigated whether the allocation of resources among incumbents and the screening of entrants in African manufacturing are driven by efficiency differences. The analysis of micro panel data from Ethiopian manufacturing shows considerable heterogeneity at the firm level, which is very similar to observations in other regions. There is also evidence that the observed patterns of firm entry, exit and survival are underpinned by productivity differences. Although efficiency is not the only factor behind the observed dynamics, data show highly efficient firms to be more likely to remain at the top of the productivity distribution, while firms at the lower tail of the productivity distribution exit more frequently. This finding corroborates research results from other developing and developed regions and shows that market selection in Africa, as represented by Ethiopia, is at least as strong as elsewhere.

In conformity with the assumptions of market selection models, most firms join an industry with a small size and at the lower end of the productivity distribution, apparently passing through a process of learning which leads either to upward movement on the productivity ladder or to exit. Since entry and exit take place predominantly among less efficient firms which are also small in size, the immediate contribution of producer turnover to aggregate productivity is rather limited. However, its long-term effect is expected to be high, by maintaining the competitive challenge on incumbents and purging inefficient producers. There is, however, a significant amount of industry rationalisation, as market shares are reallocated from less efficient to more efficient incumbents. This rationalisation process managed to counteract the negative effect of a more or less secular decline in intra-firm productivity during the study period. As a result, only a few industries exhibited a significant shift to the right in the distribution of productivity. Among the industries that managed such a positive shift, the major source of improvement was convergence toward frontier technology instead of a shift of the frontier forward. Moreover, the industries with a positive shift in productivity are among those facing strong competition from imports, suggesting that international competition has an additional disciplinary effect. It has been indicated that industries with a relatively high import penetration rate demonstrate less tolerance for inefficient firms.

It can be concluded that market selection has contributed to industrial competitiveness by playing the expected disciplinary role among African manufacturing firms. However, markets alone do not provide a sufficient condition to develop the core capabilities that a developing economy needs for long-term competitiveness. The decline in intra-firm productivity in most industries signals an important setback for industrial competitiveness and requires further investigation. Chapters 5 and 6 examine the accumulation of technological capabilities and physical capital, respectively, in an effort to shed light on the intra-firm dynamics that drive the time path of aggregate productivity.

Appendix Chapter 3

Table 3A.1: Technological classification of exports

Classification	**Examples**
Primary Products	Fresh Fruits, Rice, Tea, Coffee, Wood, Coal, Crude Petroleum, Gas
Manufactured Products	
Resource-Based Manufactures	
Agro/forest-based products	Prepared meats/fruits, beverages, wood products, vegetable oils
Other resource based products	Ore concentrates, petroleum/rubber products, cement, cut gems, glass
Low Technology Manufactures	
Textile/fashion cluster	Textile fabrics, clothing, headgear, footwear, leather manufactures, travel goods
Other low technology	Pottery, simple metal parts/structures, furniture, jewellery, toys, plastic products
Medium Technology Manufactures	
Automotive products	Passenger vehicles & parts, commercial vehicles, motorcycles & parts
Process industries	Synthetic fibres, chemical & paints, fertilisers, plastics, iron, pipes/tubes
Engineering industries	Engines, motors, industrial machinery, pumps, switchgear, ships, watches
High Technology Manufactures	
Electronics and electrical products	Office/data processing/telecommunications equipment, TVs, transistors, turbines, power generating equipment
Other high technology	Pharmaceuticals, aerospace, optical/measuring instruments, cameras
Other transactions	Electricity, Cinema film, printed matter, ‘special’ transactions, gold, art, coins, pets

Source: Adapted from Lall (2001: 92).

Table 3A.2: Technological features of export categories

Resource Based	Products tend to be simple and labour intensive, though there are segments using capital, scale and skill-intensive technologies (for example petroleum refining and modern processed foods). Competitive advantage arises generally but not always from the local availability of natural resources.
Low Technology	Products tend to have stable well-diffused technologies mainly embodied in capital equipment, with low R&D expenditures and simple skill requirements. The market as a whole tends to grow slowly, with income elasticities generally below unity, though there are exceptions such as fashion garments. Products tend to be undifferentiated and bought mainly on the basis of price competitiveness; however there are high quality segments where brand names, skills, design and technological competence are vital.
Medium Technology	Products are the heartland of industrial activity in mature economies, comprising the bulk of skill and scale –intensive technologies in capital goods and intermediaries. They generally have complex technologies, with moderately high levels of R&D, and advanced skill needs. Most require lengthy learning periods and considerable interaction between firms to reach 'best practice' technical efficiency. Barriers to entry tend to be high where there are large capital needs or strong learning effects in operation m design and product development.
High Technology	Products have advanced and fast-moving technologies, with high R&D requirements and an emphasis on product innovation. Many technologies require advanced technology infrastructures and close interactions between firms, and between firms and research institutions. However, certain electronic products have labour-intensive final assembly; their high value-to –weight ratios make it economical to relocate these processes in low-wage areas.

Source: Lall and Pietrobelli (2002).

Table 3A.3: OLS regression of (log) total factor productivity

	Coefficient.	**Std. Err.**	**T**
Medium-Sized Firms	0.466	0.080	5.860
Large Firms	0.780	0.077	10.070
Entrants	-0.106	0.079	-1.350
Continuing Firms	0.313	0.080	3.910
Import Competing	0.100	0.057	1.750
Intercept	-0.419	0.072	-5.860

Note: Firms that employ 10–29 persons are considered small, medium-sized firms employ 30–99 and large firms employ at least 100 employees. *Entrants* is a dummy variable that takes the value 1 for firms that joined the manufacturing sector after 1996 and Continuing Firms is also a dummy variable taking the value 1 for firms observed in both 1996 and 2002. *Exiting firms* are those observed in 1996 but not found in 2002. The reference category includes exiting small firms in non-import competing industries.

Notes to Chapter 3

1. An article based on this chapter is forthcoming in the January 2007 issue of *Economic Development and Cultural Change*.
2. The difference in the mean and median shows that the distribution of manufacturing value-added to GDP ratio is skewed to the right.
3. Note that their study used factor share to aggregate firm-level productivity to industry level productivity and the decomposition is based on productivity growth rather than level of productivity.
4. For a critique on this method see Ackerberg et al. (2005).
5. An alternative and widely applied method of testing market selection examines firm growth conditional on age and size. As discussed earlier, such studies investigate the implications of the selection process rather than the underlying assumptions.
6. Unlike manufacturing census data from developed countries, the Ethiopian data does not allow differentiation of the exact status of exiting firms. While some of those exiting are truly dead firms, some could simply be slipping below the 10 persons employment threshold while others are shifting their line of production to other industries in manufacturing or to an entirely different sector. Similarly, not all entrants are new firms; some are graduating into the census size category, while others are switching in from other industries or sectors. While merger is another possibility for disappearance of firms, it is very unlikely to be an important case in the Ethiopian data.
7. Notice that the transition matrices in Baily et al. (1992) are over five years while the discussion in this paper is over six years. However, results remain essentially the same for a five-year transition.
8. Comparisons with Baily et al.(1992) in the following sections are based on Appendix Table-3 with unweighted transition matrices for the period 1972 to 1977.
9. Assuming no exports, an import penetration ratio of 50% means imports equal domestic production; therefore, an import penetration ratio greater than 50% implies an imports to domestic production ratio of greater than 100%.
10. A two-sample t-test shows significantly higher firm exit rates from the 4th and 5th quintiles for industries with high import competition as compared to those with low import competition. For firms in the 1st quintile the difference in exit rate by trade orientation is also statistically significant but in the opposite direction. No significant differences were observed for firms in the 2nd and 3rd quintiles.
11. A regression of log-TFP on dummy variables representing entrants, exiters and survivors as well as dummies for firm size and import competition showed no significant productivity difference between entrants and exiters while continuing firms were significantly more productive. Firms facing high import competition were also found to be more efficient than those with relatively low import competition. See appendix table 3.3 for regression results.

4 Entry, Survival and Growth of Manufacturing Firms

4.1 Introduction

This chapter extends the analysis of market selection by providing econometric tests of its implications for firm dynamics. While the transition matrices and decomposition analysis in Chapter 3 identified productivity differences among entrants, exiting firms and incumbents, and the role of such differences in aggregate productivity growth, the discussion in this chapter focuses on the implications of the selection process in terms of firm survival and growth. Such analyses shed light on the life cycle of manufacturing firms and address the question of what determines survival and growth once firms join an industry. Understanding firm dynamics in terms of entry, survival and growth furthers our microeconomic perspective on industrial evolution and competitiveness in sub-Saharan Africa. Since each aspect of firm dynamics reflects a decision-making process, it is important to understand key elements of the information set driving these processes. Some factors operate at the firm level, while others are industry-wide effects.

The literature on firm dynamics documents important stylised facts for manufacturing industries in advanced countries. As reviewed in Geroski (1995), most industries do not seem to be short of entrants, although variation in entry rates across industries and over time is not adequately explained either by differences in profit rates or by entry barriers. Breaking through entry barriers is therefore less of a challenge for entrants than gaining survival skills, which proves very difficult (Bartelsman et al. 2003). Entry and exit also take place at the lower end of the firm size distribution, and it takes five to ten years for entrants to reach the average size of incumbents. The most immediate impact of entry is, therefore, exit rather than a reshuffling of market shares. For these reasons entry is generally a poor substitute for active competition among incumbent firms in a market (Geroski 1995).

There is, however, scant empirical evidence of these processes in the developing world and particularly for sub-Saharan Africa where only a limited number of studies have been done. This chapter constitutes an addition to the few firm-level empirical studies in Africa. Liedholm and Mead (1999) showed that entry into the micro and small enterprises sector in Africa is common, but their study says little about entry into the formal sector except that micro-enterprises rarely graduate to the small and medium size categories. McPherson (1995) reported hazard estimates for micro and small enterprises in southern Africa, yet some of his findings are out of line with the stylised facts. For instance, he found that firm exit does not depend on initial size. Frazer (2005) and Söderbom, Teal and Harding (2006) studied survival of manufacturing firms using probit models, where exit and survival are treated as discrete choice variables. They found survival to be positively associated with firm size and efficiency, consistent with market selection models and research findings from industrialised countries. However, the question of whether a firm exits a market (as analysed in probit models) is different from what determines survival time in business (an issue analysed by survival models). This chapter analyses the nature and determinants of firm entry, survival and growth in Ethiopian manufacturing using a panel of firms over the 1996–2002 period. The analysis of firm survival presented here is the first attempt for a sub-Saharan African country based on a census-derived panel data.

The chapter is structured as follows. The following section presents a descriptive analysis of the process of entry. Section 4.3 examines the survival/exit decision using the Cox proportional hazard model. Section 4.4 discusses firm growth conditional on survival and tests whether sample selection drives some of the observed relationships. By dealing with post-entry performance, the materials covered in sections 4.3 and 4.4 serve as formal tests of the implications of market selection models. Section 4.5 draws conclusions.

4.2 Firm entry

Firm entry is a key component of the market selection process as discussed in Chapter 3. Entry propagates the diversity of producers and the range of products in terms of design, quality and price. Inasmuch as competition spurs efficiency gains, a steady flow of entrants remains important, particularly in economies where a number of modern industries are either at an incipient stage or simply nonexistent. Entry could, however, be restrained not only by the actions of incumbents but also by government policies related to access to land and capital, licensing procedures and other administrative red tape. At the macro level, entry also depends on the dynamics of aggregate demand. This section provides a descriptive analysis of entry patterns in Ethiopian manufacturing and some of its determinants.

In what follows, a firm is considered an entrant if it is observed for the first time in the census of Ethiopian manufacturing. However, because of the size threshold in the census, it is impossible to distinguish firms that recently crossed the 10-person employment threshold from new establishments joining an industry for the first time. Exiters are those firms that do not reappear in a subsequent edition of the census. In the few cases where a firm disappears from the census at some point and reappears after a year or so, these are considered a continuing firm. Neither do the data distinguish firms that have closed down from those that have slipped below the 10-person threshold or those that switched to another industry within manufacturing or to other sectors outside of manufacturing. The data therefore tends to overstate producer turnover rates and the results should be interpreted with this in mind. The rate of entry is defined as the ratio of entrants to the total number of firms (incumbents plus entrants) in an industry in a given year. Similarly, the rate of exit is the share of exiting firms in the total number of firms in an industry in a given year.

Figure 4.1 shows that in Ethiopian manufacturing the average entry rate (over nine industries) is very high and closely associated with the exit rate. The degree of correlation between entry and exit is stronger (with a correlation coefficient of 0.6) when turnover is weighted by employment. Figure 4.1 also shows that entry on average is slightly higher than the exit rate, leading to a net increase in the number of producers during the study period. The correlation between entry and exit suggests that new firms tend to replace each other as most exiters are themselves young small firms. This was also documented in table 3.3 (*a* and *b*) in Chapter 3, which showed most entrants and exiting firms as located in the lower two productivity quintiles. If high rates of entry were accompanied by rapid exit, then the net effect of producer turnover on incumbents in terms of competition for market share and profits would be limited. This phenomenon is consistent with observations in a number of studies for developed countries (Geroski and Schwalbach 1991). Except for being relatively high, entry into Ethiopian manufacturing and its relation with exit is similar to the process in established market economies. Since a high entry rate does not imply a high market penetration rate,

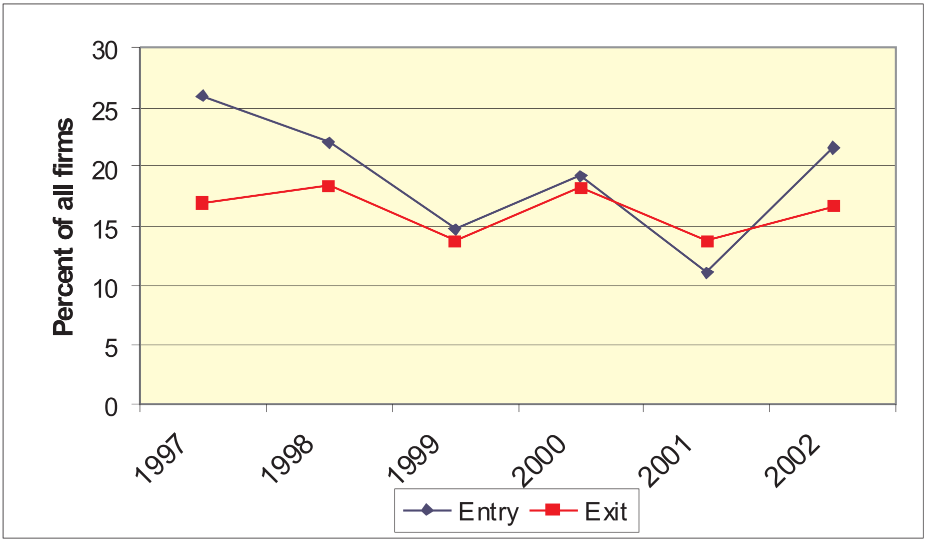


Figure 4.1: Average entry and exit rates in Ethiopian manufacturing

Source: Author's computations based on CSA manufacturing census.

due to small size of entrants (Geroski 1995), the role of entry appears to be more one of maintaining market contestability, i.e., posing a potential threat to incumbents. Figure 4.1 shows a gently declining trend in entry rate from 1997, with a recovery in 2002.

The entry rate tends to decline with average firm size (measured in terms of employment) in an industry. Figure 4.2 shows that industries dominated by large enterprises (hence higher mean firm size) generally have lower entry rates. This suggests that scale economies and market concentration tend to act as entry barriers protecting incumbents. There are also important inter-industry differences in entry rate as shown by the clustering of industries in figure 4.2. Entry rates in excess of 30% are recorded in the wood and furniture (code 5) and metal industries (code 9), where the average firm size is about 50 employees. Most industries have an average firm size of close to 100 employees and entry rates of about 20% per annum. These include the non-metal (code 8), printing and paper (code 6) and light machinery (code 10) industries. At the other extreme is the textile industry (code 3) with average firm size of more than 500 employees and an average entry rate of about 10% (the average firm size for the textile industry in the figure is scaled down by half for purposes of illustration). As would be expected, capital intensity appears to play a role in driving inter-industry differences in entry rates. As shown in table 2.1, wood and furniture is the least capital-intensive industry, and it has one of the highest entry rates (figure 4.2), while the lowest entry rates are observed in the chemical industry (code 7), which is highly capital intensive. But this does not tell the whole story: the food and beverage industry (code 1), for instance, is twice as capital intensive as the leather and footwear industry (code 4), but the former has a relatively higher entry rate than the latter.

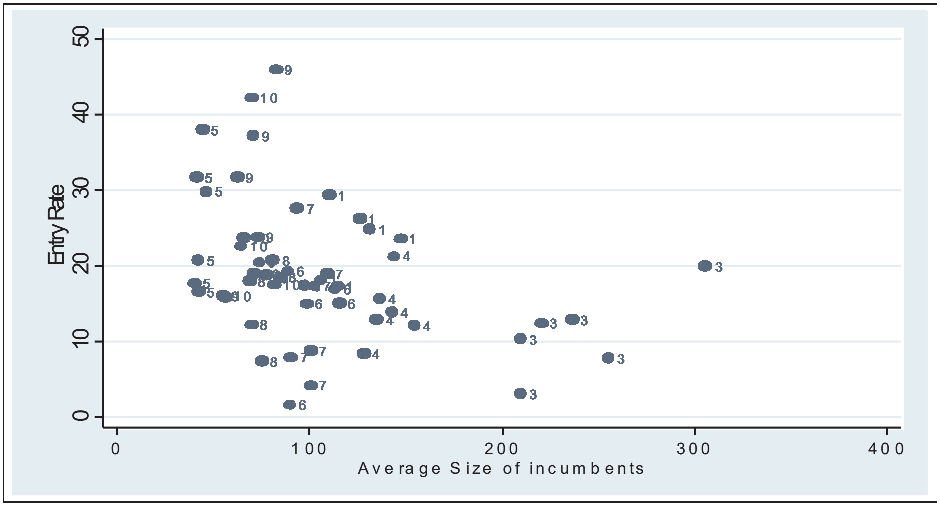


Figure 4.2: Average rate of entry and average size of incumbents

Source: Author's computations based on CSA manufacturing census.

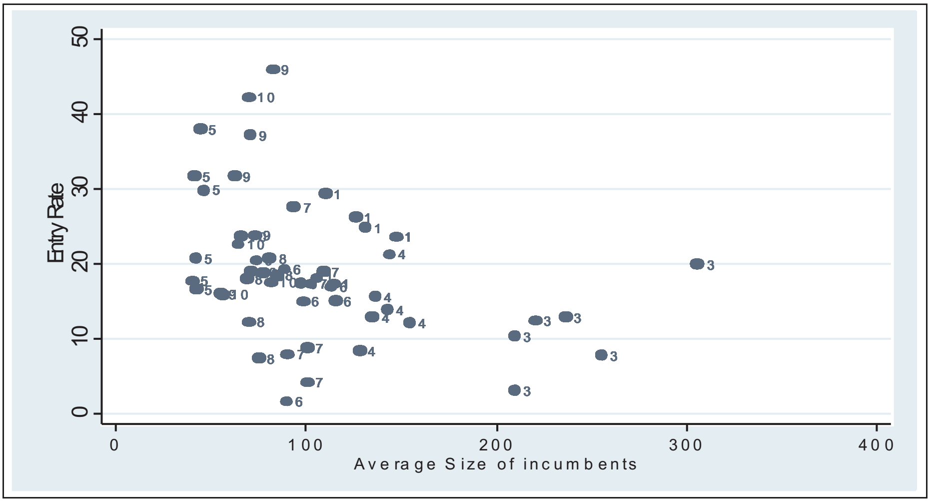


Figure 4.3: Average size of entrants and incumbents (industry level)
Source: Author's computations based on CSA manufacturing census.

Another observation is that industries with relatively high average firm size tend to attract fewer but relatively larger entrants. The average size of entrants increases with the average size of incumbents (figure 4.3), which partly explains why entry in industries with relatively large firms is relatively low.

To conclude, it can be said that despite a mild declining tendency, the observed rate of entry in Ethiopian manufacturing lies within the 15% to 20% rate.[1] This is close to the average entry rate of about 20% reported for other developing countries (World Bank 2005). Although this does not mean that there are no entry barriers for small firms, it shows that entry is not a major problem or entry barriers are not too restrictive in Ethiopia as compared to other countries. The real issue is therefore what happens post-entry in terms of survival and growth – issues addressed in the following two sections.

4.3 Firm survival

4.3.1 The literature on survival

Once in the market, firms face varying levels of exit risk. Theoretical models of industrial evolution like the passive learning model of Jovanovic (1982) and the active learning model of Ericson and Pakes (1995) predict that small firms die more often than their large counterparts in the same industry. On the other hand, as time goes by, firms acquire competitive skills and the risk of failure begins to decline. From these models we understand that initial size and age are important predictors of firm survival. A statistically significant positive coefficient on indicators of size and age would therefore constitute a statistical test for market selection. On the other hand, the business strategy literature suggests that small firms do not need to grow in size in order to survive. The argument is that small firms have the advantage of flexibility and the capability to specialise in niche markets, giving them strategic advantages to overcome business failure (Porter 1990, Caves and Porter 1977).

Most empirical studies, however, find significantly positive age and size effects on firm survival supporting the market selection view (Geroski 1995 reviews such studies). On the other hand, estimates of production functions for developing country manufacturing firms do not seem to find any significant (or only very mild) scale economies in production, suggesting that small firms may not, after all be particularly at a disadvantage in most industries (Biggs et al. 1995, Little et al.1987, Tybout 2000). Similarly, for micro and small enterprises in southern Africa, McPherson (1995) found no significant size effect on survival. The survival-size relationship therefore remains inconclusive in both the theoretical and empirical literature.

Underlying the previous discussion is the role of productivity in determining firm survival. If markets work properly, competition would purge industries of inefficient producers. While this might be generally the case, efficiency does not seem to explain the entire survival story. For a group of five African countries, quite a large proportion of exiting firms closed down for non-business reasons, such as the death of the owner or opening up of better opportunities elsewhere (Liedholm et al. 1994). This finding, however, was based on a sample of micro and small enterprises only. We also saw in Chapter 3 that, although firm exit in Ethiopian manufacturing occurs predominantly at the lower end of the productivity distribution, some 10% of exiting firms were in the most efficient quintile in the initial period (in 1996).

Foreign investment is another determinant of survival time. While foreign investment tends to enhance efficiency and hence prolong survival time, one would expect foreign firms to be more footloose and inclined to exit the market when the domestic economy is in trouble or they find better business opportunities elsewhere. When it comes to capital intensity, standard trade theory predicts that capital-intensive industries in economies relatively abundantly endowed with labour would contract or disappear unless they are protected from international competition. On the other hand, more capital per person could enhance labour productivity and reduce the hazard of failure. The latter is a view supported by theories of industrial evolution that relate firm survival and growth to investment in productivity-enhancing activities (Olley and Pakes 1996, Ericson and Pakes 1995). The ultimate effect of foreign direct investment and capital intensity on firm survival is therefore an empirical question.

Researchers have also been interested in understanding the link between export and productivity. While there is evidence that efficient producers are selected into export markets, firms also learn from exporting and thus improve their productivity. However, few studies relate firm survival to export performance. Exporters in US manufacturing, for instance, are not only more productive but also face lower risk of failure (Bernard et al. 2002). In countries with low international reserves, dependence on imported inputs may be a source of instability and higher risk of failure. On the other hand, using imported inputs may provide a competitive edge if such imports involve a technological advantage. The effect of imported inputs is therefore difficult to determine a priori. The empirical model in this chapter controls for these covariates to find out their effect on firm survival. Following some of the empirical literature on survival analysis, this chapter also looks at the importance of product differentiation as a firm strategy to secure market position and prolong survival.

Other covariates of firm survival are industry specific, such as industry growth and competition from imports. Entrants would stand a better chance of survival if the industry they join enjoys growing demand and is expanding. On the other hand, industries that are exposed to more competition from imports may encounter higher risk of exit than protected industries – the main reason behind protective trade policies.

4.3.2 Duration models

This section uses duration models to analyse survival time. The analysis of survival time has a long tradition in biometrics and materials science. Its application in economics is rather recent, having started with the analysis of spells of unemployment conditional on personal and labour market characteristics. Its application to firm demographics is even more recent and started with the works of Troske (1989) and Audretsch and Mahmood (1994). The subject of analysis is the population distribution of time under risk – in our case the risk of firm exit. The cumulative density function $F(t)$ of time under risk or survival time (T) is given as follows:

$$F(t) = P(T \leq t), \quad t \geq 0 \qquad (1)$$

where t is a specific value of T.

The survivor function (S) is defined as the probability of surviving past time t:

$$S(t) \equiv 1 - F(t) = P(T > t) \qquad (2)$$

In most econometric analyses however the prime interest is in the hazard function which expresses the probability of failure in a short time interval Δt conditional on surviving until t. The hazard function $\lambda(t)$ is expressed as follows:

$$\lambda(t) = \lim_{\Delta\tau \to 0} \frac{P(t \leq T < t + \Delta t | T \geq t)}{\Delta t} \qquad (3)$$

It is interesting to note that the hazard and survivor functions are closely related as in the following expression:

$$\lambda(t) = \lim_{\Delta t \to 0} \frac{F(t+\Delta t) - F(t)}{\Delta t} * \frac{1}{1-F(t)} = \frac{f(t)}{S(t)} \tag{4}$$

where $f(t)$ is the density of T.

The shape of the hazard function conveys an important message about the underlying distribution of survival time. In cases where the derivative of the hazard function with respect to time is positive, i.e., $d\lambda(t)/dt > 0$, there is a positive duration dependence, meaning that the risk of failure increases with time. If the derivative is less than zero, there is negative duration dependence and agents will be more likely to survive as time goes by. The event being studied is said to be "memoryless" if the derivative of the hazard is equal to zero.

Depending on the expected shape of the hazard function (or the distribution of survival time), different methods can be used to estimate a conditional hazard function. The Weibull function is the most popular one, which can assume memoryless, positive and negative duration dependence functions depending on the values of the parameters of the Weibull distribution.[2]

The preceding expressions have not been linked to explanatory variables. To test the implications of market selection models and other control variables we need a conditional hazard function. A conditional hazard function is an expression of the risk of failure conditional on some explanatory variables:

$$\lambda(t;x) = \frac{f(t|x)}{1-F(t|x)} = \frac{f(t|x)}{S(t|x)} \tag{5}$$

where X is a vector of explanatory variables and $f(.|x)$ is the density of T given X. Our interest here is on the partial effects of the explanatory variables on the hazard function (Wooldridge 2002). Unlike the case of machine lifetime where the risk of failure is known to follow a positive duration dependence, there is no definite a priori expectation about the shape of the hazard function when it comes to firm exit. There is, however, a class of models that allows analysis of shifts in the hazard function conditional on time-invariant explanatory variables. These are proportional hazard models of which the most popular is the one provided by Cox (1972). The extended Cox model imposes the hazard proportionality condition, which makes it possible to estimate coefficients of covariates without having to specify the underlying hazard function. It starts by defining a baseline hazard function $\lambda_0(t)$ which is common to all subsamples and not affected by any covariate. The hazard of each subsample $\lambda_i(t)$ is assumed to be a certain proportion of the baseline hazard and this proportionality is expressed as a function of covariates.

$$\frac{\lambda_i(t)}{\lambda_0(t)} = \exp(\beta' x_i) \tag{6}$$

Equation (6) is the proportional hazard model, and its logarithmic expression gives us a linear model that can be estimated by maximum likelihood method:

$$\log \lambda_i(t) = \log \lambda_0(t) + \beta' x_i \qquad (7)$$

The coefficients in (7) can be expressed as hazard ratios in which case a value of $\beta = 1$ represents a covariate that does not affect the hazard ratio. A coefficient greater than one implies that the variable increases the risk of exit while a value less than one reduces the hazard of failure or prolongs survival time. In applications where the actual regression coefficients are reported, a covariate with a negative (positive) coefficient reduces (increases) the risk of exit.

4.3.3 Model specification

The hazard model to be estimated is guided by the earlier discussion in section 4.3.1. Initial firm size is an important explanatory factor and its effect is captured through dummy variables distinguishing small, medium and large enterprises. Small enterprises are firms that have 10 to 29 employees, while medium-sized firms have 30 to 99 employees. Firms that employ at least 100 persons are considered large. In all models, small firms are the reference group. Similarly, the age effect is captured through dummies representing five age groups (in years): 0–4, 5–9, 10–19, 20–29 and lastly firms that are at least 30 years old.

The firm productivity index is derived from the production function discussed in detail in Chapter 3 (section 3.3). This chapter uses two approaches to test the effect of productivity on survival. The first is to include the firm-level productivity index directly in the survival model. This is done in specifications 1 through 6. The second approach is to use quintile dummies where quintile 1 is the most productive quintile. Specifications 7 and 8 are based on the latter approach.

The model includes a dummy variable that identifies firms with foreign ownership. The dummy variable takes the value 1 if there is a positive amount of foreign capital, and it is 0 otherwise. Similarly, the investment dummy identifies firms with non-zero investment. The model also includes a dummy that distinguishes between public and private enterprises. In the same way, product differentiation is proxied by a dummy variable that distinguishes firms that advertise their products from those that do not. Firm participation in export markets is captured by an export dummy which takes the value 1 for exporting firms and 0 for those that serve only the domestic market. Exposure to international competition is captured by the import penetration ratio. Firms with an import penetration ratio in excess of 50% are considered to be high-competition industries compared to those with import penetration rates of less that 50%. Capital intensity is simply capital per person employed while import intensity measures the proportion of imports in the total value of inputs. Industry growth is measured in terms of output growth.

The survival model is estimated over two samples. The first sample includes firms with an entry date not more than three years before 1996. The three-year lag allows for delays in firms' appearance in the annual manufacturing census after their establishment, as it is assumed that their initial conditions do not change dramatically in a three year period. This sample restricts the analysis to firms whose entry/initial conditions are observed as required in a proportional hazard model. The other group of estimates is based on the entire sample, which also includes old firms whose initial conditions are not reported in the data. For these firms the analysis regards the 1996 data as their initial values.

4.3.3 Results

Results of non-parametric analysis

Figures 4.4 and 4.5 provide a preliminary insight into the hazard and survivor functions from the Ethiopian data. Figure 4.4 reveals that in general the exit hazard increases during the first few years after entry and starts to decline afterwards. Considering all firms (panel d), the risk of failure reaches its peak at about four years. The tipping point is a little longer for small enterprises and a little shorter for medium and large enterprises. That is, for medium and large enterprises, the risk of failure begins to decline once they pass the three and a half year threshold while for small enterprises the hazard rate keeps rising until four and a half years

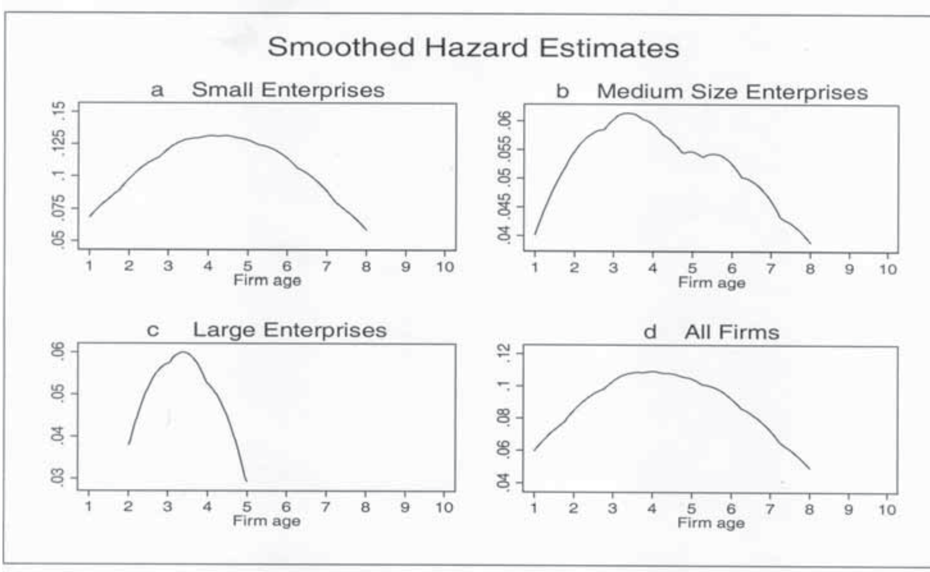


Figure 4.4: Smoothed hazard estimates for Ethiopian manufacturing
Source: Author's computations based on CSA manufacturing census.

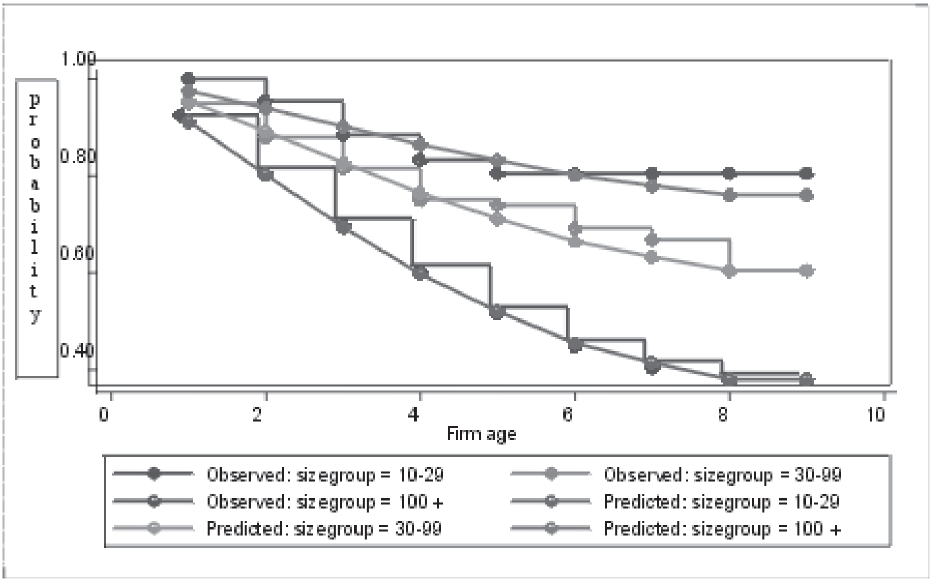


Figure 4.5: Comparison of Kaplan-Meier and Cox survival curves

Source: Author's computations based on CSA manufacturing census.

of age. The observed pattern is consistent with theoretical expectations and empirical findings for other countries.

Figure 4.5 compares the survivor function for small, medium and large enterprises. The figure shows that survival rate increases with firm size: the top pair of lines is the survival probability for large firms, while the bottom pair is that for small firms. Although the survivor function is another side of the hazard function, figure 4.5 serves the additional purpose of testing the hazard proportionality assumption. The graph shows that the curves predicted from the Cox regression (the doted straight lines) are similar to the descriptive graphs based on the Kaplan-Meier estimates (the staircase lines). This similarity, together with the nearly parallel nature of the Cox curves for the three size categories, indicates that for this variable the assumption of hazard proportionality is not violated. Notice that survival among small firms is far lower than that for both medium and large firms, a fact also reflected in figure 4.4.

In the appendix to this chapter, figure 4A.1 provides additional graphs with survival probabilities for some of the explanatory variables in the survival model. It shows that survival probabilities are higher for firms that export, advertise their products and undertake some investment. Firms with some FDI also survive longer than those with no FDI, while exposure to import competition does not seem to make a difference. Compared to privately owned firms, public enterprises also seem to stand a better chance of survival.

Results of Cox proportional hazard model

The following discussion refers mainly to the results in table 4.1, which includes firms that were less than 10 years old in the year 2002. Refer to table 4.2 for regression results based on all firms regardless of age. While columns 1–6 include the firm-level productivity index, columns 7 and 8 report regression results based on a ranking of productivity in quintiles. The results in column 8 are stratified by region and industry, while the other models (1–7) are stratified by region only. Notice that the tables report hazard ratios and their standard errors. However, the significance of each variable is determined based on the p-values of the underlying natural regression coefficients, which are not reported here. Therefore, some variables marked as statistically significant in the tables may appear insignificant upon visual inspection of the hazard ratio and its standard error.[3]

Consistent with theoretical models and other empirical studies, size turned out to be an important determinant of firm survival. The risk of exit among medium-sized firms is some 40% to 50% less than that among small enterprises, while being large reduces the hazard to about one-quarter to one-third. In contrast, McPherson (1995) shows no size effect for a group of African countries; and this difference has to do with his sample being restricted to micro and small enterprises. Table 4.1 also shows that passing the four-year threshold reduces the hazard of exit by about 70%, consistent with the observation in figure 4.4 After controlling for the effects of firm size and age, productivity has a statistically significant effect in reducing the exit hazard. This is particularly true in the regression results in table 4.2, which includes firms in all age groups. For firms that had entered the industry since 1993, the results in specifications 7 and 8 of table 4.1 show that firms in the bottom quintile have significantly higher risk of failure than those in the most efficient quintile. The hazard is also higher in the other quintiles, although the hazard ratio is not significantly greater than one. In general, the sign and significance of the coefficients on size and productivity conform with theories of market selection showing that markets do select efficient firms.

Although few firms in Ethiopia have non-zero foreign investment (about 4%), the probability of exit among them is considerably lower than for firms fully owned by Ethiopians. Similarly, the risk of exit among public enterprises is lower than that among private entities. This indicates that although the public enterprises reform carried out since 1992 claims to have put state-owned enterprises on the same footing as the private sector (in terms of resource allocation), public enterprises still seem to enjoy a more secure business environment, even after controlling for the size effect.

Firms that invested during the study period were able to prolong their survival time compared to non-investing firms, regardless of the magnitude of investment. It is interesting to note that the proportion of firms with some level of investment declined, particularly for small and medium-sized firms, during the study period. The results of the Cox regression suggest that reversing this trend could improve survival rates. However, the capital intensity of firms has no significant impact on the risk of failure. It seems that firms can freely choose their factor intensities without any implication for their chances of survival. Perhaps what actually matters is whether there is sufficient demand for their products.

On the other hand, product differentiation plays a critical role in reducing the hazard of exit as captured by the coefficient of the advertisement dummy. It seems that firms that invest in strategic advantages and make their cutting edges known to consumers stand a better chance of survival. Related to this, the risk of failure tends to decline with market share. This is interesting because it indicates that firm growth does not necessarily translate into increased market share, especially if the industry is expanding, unless firms make an extra effort to secure and expand market share through such activities as advertising.

Exporting firms in Ethiopian manufacturing do not fare any better or worse than non-exporters in terms of survival. This is unlike the United States, where exporting firms stand a better chance of survival (Bernard et al. 2002). This has perhaps to do with the fact that leather and footwear is the only industry with significant exports in Ethiopia. The expected "learning through exporting" in this industry is likely to be limited since the basis for export lies in the country's abundant livestock resources and the natural attributes of its leather. Similarly, dependence on imported inputs does not appear to expose domestic firms to a higher risk of failure. This might be explained by the improved access to foreign reserves since the introduction of the economic reform programme in 1991.

Turning to industry-specific factors, it turns out that firms in industries that face higher competition from imports have a better chance of survival, but this effect is not statistically significant. This suggests that the widely held expectation of developing country firms going out of business following trade liberalisation does not have strong empirical support in the case of Ethiopia. At least for some industries, there are indications that imports and domestic firms aim at different segments of the market. In the wood and furniture industry, for instance, imports serve the upper end of the market, which is predominantly quality-oriented, while domestic firms target the demand from households, schools and health facilities. Although this industry has a high import penetration rate, it is hard to say that domestic firms and imports compete for the same market. It is therefore unsurprising that some of the major domestic producers are also importers of furniture. However, as discussed in the next section, competition from imports does tend to slow firm growth. Another industry-specific variable considered in this study is output growth. Surprisingly, industry growth is positively associated with the risk of business failure. This outcome is possible if a decline in industry-level output is accompanied by a reshuffling of market share without an increase in exit rate. Another possibility is that growing industries attract more small entrants which will soon exit the market, hence increasing the exit rate. The earlier discussion, in section 4.2, lends some support to the latter claim.

Table 4.1: Results of Cox regression for Ethiopian firms (hazard ratios for a sample of entrants since 1993)

	1	2	3	4	5	6	7	8
Medium	0.461***	0.486***	0.586***	0.598***	0.565***	0.563***	0.573***	0.608**
	(0.081)	(0.086)	(0.106)	(0.110)	(0.113)	(0.113)	(0.115)	(0.127)
Large	0.230***	0.253***	0.319***	0.341***	0.367**	0.374**	0.364**	0.355**
	(0.083)	(0.092)	(0.122)	(0.133)	(0.150)	(0.154)	(0.150)	(0.158)
Age 5–10 Years	0.356***	0.356***	0.278***	0.273***	0.276***	0.287***	0.291***	0.281***
	(0.067)	(0.067)	(0.053)	(0.052)	(0.053)	(0.055)	(0.056)	(0.060)
Productivity		0.894**	0.923	0.928	0.932	0.936		
		(0.046)	(0.048)	(0.049)	(0.051)	(0.050)		
Public Enterprise			0.645	0.662	0.702	0.688	0.698	1.238
			(0.486)	(0.497)	(0.532)	(0.523)	(0.531)	(0.972)
Foreign Capital			0.535	0.534	0.533	0.412*	0.400**	0.448*
			(0.243)	(0.242)	(0.243)	(0.192)	(0.187)	(0.218)
Investment			0.413**	0.410***	0.404***	0.399***	0.410***	0.432***
			(0.050)	(0.050)	(0.051)	(0.050)	(0.052)	(0.058)
Capital Intensity				1.000	1.000	1.000*	1.000*	1.000***
				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Advertising				0.908	0.903	0.931	0.938	0.913
				(0.135)	(0.138)	(0.143)	(0.144)	(0.152)
Market Share					0.949	0.947	0.956	0.941
					(0.083)	(0.082)	(0.082)	(0.069)
Export					1.303	1.003	0.933	1.121
					(0.629)	(0.496)	(0.462)	(0.611)
Import Intensity					1.001	1.005	1.005	1.029*
					(0.002)	(0.004)	(0.004)	(0.015)
Import Competing						0.720	0.713	1.000
						(0.182)	(0.180)	
Industry Growth						1.008***	1.008***	1.011***
						(0.002)	(0.002)	(0.003)
Productivity Ranking								
2nd Quintile							1.375	1.496
							(0.392)	(0.443)
3rd Quintile							1.535	1.526
							(0.413)	(0.436)
4th Quintile							1.115	1.286
							(0.301)	(0.364)
5th Quintile							1.586*	1.789**
							(0.415)	(0.493)
Log Likelihood	-1444.0	-1442.0	-1413.0	-1412.0	-1364.0	-1354.0	-1351.0	-834.2
LR (p value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subjects	741	741	741	741	732	732	732	732
Observations	2022	2022	2022	2022	1991	1991	1991	1991

Notes: *** significant at 1% ; ** significant at 5%; * significant at 10%. Standard errors in parenthesis. All regression models are stratified by region except column 8, which is stratified by region and industry.

Table 4.2 : Results of Cox regression for Ethiopian firms (hazard ratios for the entire sample)

	1	2	3	4	5	6	7	8
Medium	0.452***	0.491***	0.616***	0.656***	0.662***	0.661***	0.658***	0.714**
(30-99)	(0.058)	(0.063)	(0.082)	(0.091)	(0.092)	(0.092)	(0.092)	(0.106)
Large (100 +)	0.136***	0.153***	0.238***	0.339***	0.337***	0.320***	0.313***	0.314***
	(0.031)	(0.035)	(0.065)	(0.096)	(0.098)	(0.093)	(0.091)	(0.101)
Age 5-9	0.397***	0.395***	0.319***	0.312***	0.311***	0.307***	0.306***	0.312***
Years	(0.046)	(0.045)	(0.038)	(0.037)	(0.037)	(0.037)	(0.037)	(0.041)
10-19	0.0 52***	0.051***	0.039***	0.035***	0.035***	0.034***	0.034***	0.023***
Years	(0.011)	(0.011)	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)	(0.006)
20-29	0.006***	0.007***	0.005***	0.004***	0.004***	0.004***	0.004***	0.002***
Years	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
30+	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.000***
Years	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Productivity		0.853***	0.884***	0.908***	0.911**	0.904***		
Index		(0.030)	(0.032)	(0.034)	(0.035)	(0.034)		
Public			0.687	0.755	0.746	0.770	0.776	0.848
Enterprise			(0.171)	(0.188)	(0.188)	(0.195)	(0.196)	(0.248)
Foreign			0.543**	0.643	0.637	0.610	0.618*	0.557*
Capital			(0.163)	(0.193)	(0.192)	(0.184)	(0.187)	(0.182)
Investment			0.422***	0.441***	0.438***	0.430***	0.432***	0.453***
			(0.037)	(0.039)	(0.039)	(0.038)	(0.038)	(0.043)
Capital				1.000**	1.000*	1.000***	1.000***	1.000***
Intensity				(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Advertisement				0.733***	0.714***	0.730***	0.733***	0.717***
				(0.084)	(0.083)	(0.085)	(0.086)	(0.091)
Market				0.870**	0.867*	0.882*	0.892	0.898
Share				(0.066)	(0.068)	(0.066)	(0.066)	(0.065)
Export					1.011	0.952	0.933	0.874
					(0.404)	(0.383)	(0.376)	(0.389)
Import					1.002	1.006**	1.006**	1.037***
Intensity					(0.001)	(0.003)	(0.003)	(0.010)
Import						0.667**	0.682**	1.000
Competition						(0.107)	(0.109)	
Industry						1.005***	1.005***	1.005***
Growth						(0.001)	(0.001)	(0.002)
Productivity								
Rank								
2nd Quintile							1.453**	1.402*
							(0.255)	(0.264)
3rd Quintile							1.602***	1.465**
							(0.272)	(0.269)
4th Quintile							1.313	1.326
							(0.227)	(0.245)
5th Quintile							1.746***	1.699***
							(0.294)	(0.309)
Log Likelihood	-2886	-2876	-2822	-2740	-2728	-2718	-2715	-1630
LR (p value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Subjects	1439	1439	1439	1421	1420	1420	1420	1420
Observations	4829	4829	4828	4753	4747	4747	4747	4747

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

4.4 Firm growth

The rate of growth of surviving firms has long been investigated with great interest. Firm growth is not only an important indicator of post-entry performance, it also plays a crucial role, along with entry and exit, in determining the structure and degree of competition within an industry. For instance, concentration is unlikely to rise and may even fall if the rate of entry increases and small surviving firms grow faster than larger ones. On the other hand, concentration tends to rise faster (and competition to decline) if large firms grow faster than small ones and the latter exit more often than the former (Dunne and Hughes 1994).

Earlier empirical models suggested that firm growth is a random process that is independent of firm size. Gibrat's Law of Proportional Effect states that the expected value of the increase in firm size is proportional to the current size of the firm (Sutton 1997). Gibrat and others showed that this stochastic growth process generates a size distribution of firms which is approximately lognormal. Early tests on stochastic growth models thus relied on investigating the shape of the size distribution of firms. This approach has been deemed weak, however, as it does not test the growth-size relationship directly (Hall 1987).

Studies during the 1950s and 1960s examined the relationship between firm growth and size directly using panel data, and the results raised serious doubts about Gibrat's Law, as most ran against it. Nonetheless, those studies themselves suffered from econometric problems like sample selection bias and heteroscedasticity. Empirical studies since the 1980s (Evans 1987a,b, Hall 1987) have focused on correcting these empirical problems. In effect, these later studies investigated whether the rejection of Gibrat's Law was the result of sample selection bias, as put forward by Mansfield (1962). These studies confirmed, however, that firm growth rate, conditional on survival, decreases with size and that this outcome is not an artefact of selection bias. Gibrat's Law nonetheless seems to hold better for samples restricted to large firms.

This study investigated the relationship between firm size and growth in the same panel of Ethiopian manufacturing firms used in the survival analysis. Both firm size and growth were measured in terms of number of employees, as is common practice in firm growth models. This is perhaps due to several reasons: the social import of job creation and destruction, the relative ease with which employee numbers can be measured (particularly when it comes to small firms) and the fact that employee numbers are less contaminated with prices than other measures of growth, such as sales.[4] The purpose of the analysis here is to understand the firm growth process more thoroughly and to test whether it reflects an underlying market selection process or a random distribution of growth as suggested by Gibrat's Law. It also allows us to explore the relative importance of other growth determinants. It is useful to recall here that market selection models predict that small firms will grow faster than large firms, and a number of firm-level studies from developed and developing countries seem to support this view.

4.4.1 Growth regression model

To investigate growth of manufacturing firms in Ethiopia conditional on initial size and age, the growth equation is given as follows:

$$\ln\left[S_t \big/ S_{t'} \right] \Big/ \left[t - t' \right] = \beta' X_i + u_i \qquad (8)$$

where S_t is current size, $S_{t'}$ is initial size, $t - t'$ is the number of years between the two periods, X_i is a vector of explanatory variables including initial age and size, β' is a vector of regression coefficients and u_i is a zero-mean, constant variance disturbance term.

The problem with equation (8) is that the dependent variable is observable only for firms that existed in both period t and t'. For firms that exited the industry between these two dates, no growth rate is observable. Estimating the regression coefficients under this condition would not have been a problem if firm exit was a random process or the rate of exit was empirically insignificant. Figure 4.2 shows that the exit rate is about 15%, which is significant. Studies for other countries similarly show that slow-growing small firms are more likely to exit the market than slow-growing large firms. Such a non-random attrition effect introduces a selection bias in the sample even before starting the analysis.

Heckman's (1979) two-step estimation method has been widely used to correct sample selection bias. It starts by first estimating a selection model using the probit estimator. To do so, let's rewrite the growth regression again:

$$G_i = \frac{\ln S_t - \ln S_{t'}}{\left[t - t' \right]} = \beta' X_i + u_i \qquad (9)$$

As indicated, a survival model underlies this growth model, which can be represented as follows:

$$Y_i = \alpha' Z_i + v_i \qquad (10)$$

where Z_i is a vector of explanatory variables, α'_i is a vector of coefficients, $u_i \sim N(0,\sigma)$, $v_i \sim N(0,1)$ and $corr(u_i, v_i) = \rho$. Notice that Z_i may include X_i.

The growth rate G_i is observable if the latent variable $Y_i > 0$. Hechman's model therefore estimates the expectation of growth conditional on survival:

$$E\left[G_i | Y_i > 0 \right] = E\left[G_i | v_i > \alpha' Z_i \right] \qquad (11)$$

$$= \beta' X_i + E\left[u_i | v_i > -\alpha' Z_i \right] \qquad (12)$$

$$= \beta' X_i + \rho \sigma_v \lambda_i \left(\frac{-\alpha' Z_i}{\sigma_u} \right) \qquad (13)$$

$$= \beta' X_i + \beta_\lambda \lambda_i \left(\frac{-\alpha' Z_i}{\sigma_u} \right) + w_i \qquad (14)$$

where $\lambda_i(.)$ represents the inverse Mills ratio $\frac{\phi^{\alpha' Z_i / \sigma_u}}{\Phi\left(\alpha' Z_i / \sigma_u\right)}$ and $\phi(.)$ and $\Phi(.)$ represent the normal density and the cumulative density function, respectively.

Equation (14) therefore transforms what was a sample selection bias into an omitted variable bias, the omitted variable being $\lambda_i\left(\frac{-\alpha' Z_i}{\sigma_u}\right)$. Notice that a positive correlation between the stochastic disturbances in equations (8) and (10) will lead to an upward bias in firm growth. A zero correlation ($\rho = 0$) would mean that there is no selection bias, although initial size and age may be significant in both the growth and survival equations.

Ideally one would have a variable that identifies the selection correction term to solve the selectivity bias. This study has no such variable that affects survival but does not influence firm growth. Identification is therefore based on differences in functional forms, though this is obviously a weak basis for identification. The strategy followed in this study is to include in the firm growth regression variables that feature in the survival model, and explore their effect on the selection correction term. To this end, three models were tested (table 4.4). For each model, OLS estimates were juxtaposed with estimates from a Heckman selection correction model. The first model (Model I) includes only initial age and size, as well as their quadratic terms to control for potential non-linearity in the relationship. This model has been tested in several firm growth regression studies in the literature and serves as a benchmark. The second model (Model II) expands on the basic model by including a productivity term and market share; two continuous variables that feature in the survival model. The third model (Model III) includes dummy variables indicating whether a firm exports, faces high import competition, has some foreign capital, is a public enterprise, has invested and advertises its product. In addition, all models control for industry and region effects.

Before we look at the regression results it is useful to view some descriptive statistics on firm growth in terms of employment. Figure 4.6 shows that total manufacturing employment in Ethiopia stagnated during the study period with a slight tendency to decline due to contraction of employment in large enterprises (those employing at least 100 persons). Total employment in small and medium-sized enterprises, on the other hand, grew during the study period, preventing a decline in total manufacturing employment.

Table 4.3 shows that a great majority of small firms (86.3%) experienced employment growth during the period 1996–2002. The proportion of firms with a positive growth rate, however, declines with firm size. Only 61% of medium-sized enterprises and 30% of large enterprises had positive employment growth during the study period. Overall, about 30% of firms had shed labour, most of these being large firms. As a result, the average firm size in Ethiopian

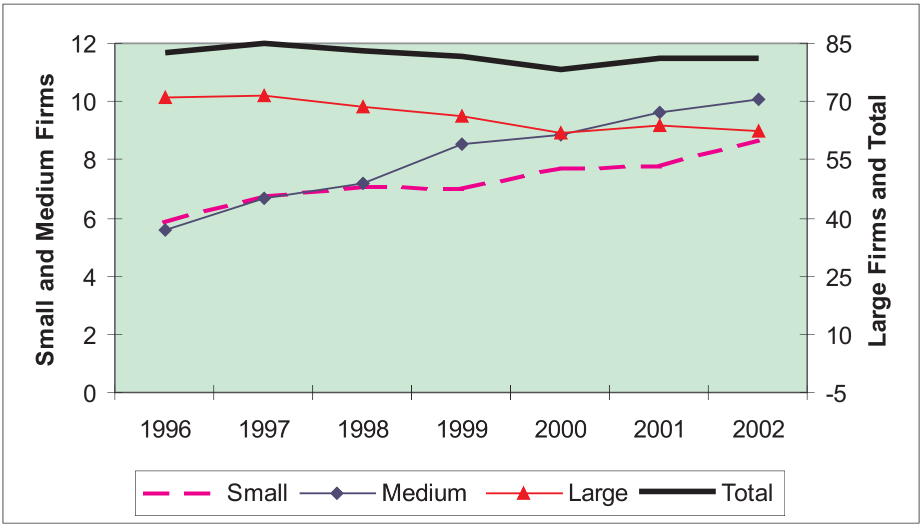


Figure 4.6: Total manufacturing employment by firm size category
Source: Author's computations based on CSA manufacturing census.

manufacturing declined steadily from 136 employees in 1996 to 98 in 2002. This observation constitutes a preliminary indication that growth does decline with firm size, at least in this sample.

4.4.2 Results of firm growth regression

The growth regression was carried out for the period 1996–2002. Table 4.4 reports OLS estimates in juxtaposition with the coefficients of the selection correction model. Table 4.5, on the other hand, presents the partial derivatives of growth with respect to size and age estimated at the sample means.

It is interesting to note that the coefficient of the inverse Mills ratio is negative and statistically significant in Model I, which includes only age and size effects. This is because of a negative correlation between the error disturbances of the growth and the selection models (see the sign of ρ). It suggests that there are unobserved features that tend to increase (decrease) the exposure to business failure

Table 4.3: Proportion of firms with positive and negative employment growth rates (1996–2002)

	Negative (%)	**Positive (%)**
Small	13.70	86.30
Medium	39.22	60.78
Large	69.57	30.43
Total	30.74	69.26

Source: Author's computations based on CSA manufacturing census.
Note: About 3% of small and medium-sized enterprises had zero growth rates for this period.

while at the same time increasing (decreasing) firm growth. This is unlike the results in Hall (1987) and Evans (1987), which find zero (or a positive but statistically insignificant) value for ρ, suggesting no selection bias despite the fact that exiting firms in their sample were slow-growing small firms. This study finds similar results in Model II and Model III, which include other covariates. Including firm productivity and market share in Model II renders the selection effect insignificant, although it still has a negative sign. In Model III, which includes all of the variables that feature in the selection model, the coefficient of λ becomes positive but statistically insignificantly different from zero. These results suggest that the unobserved selection effect is not a problem and that OLS results are as applicable to exiting firms as they are for surviving ones.

Turning to the main story in table 4.4, firm size is shown to have a significant negative effect firm size is shown to have a significant negative effect on firm growth in all specifications. Small firms, therefore, grow faster than large firms although the negative size effect tends to decline beyond a certain threshold, as indicated by a significant positive coefficient on the quadratic term. Gibrat's Law of Proportional Growth therefore does not hold for the Ethiopian sample, although the positive coefficient on the squared term indicates that Gibrat's Law tends to hold better among larger firms. Due to the selection bias, OLS estimates in Model I appear to understate the negative effect of initial size on firm growth. Looking at the partial derivate of growth with respect to size, table 4.5 shows that except for OLS estimates in Model I, over a period of 10 years a 1% increase in initial size at the mean leads to about 0.4% growth in size.[5] Small firms, thus, grow faster than larger ones and the result is not driven by the way firms are selected for our sample. This finding is also consistent with results of other studies that control for sample attrition. Most importantly, the Ethiopian data is consistent with the implications of market selection models, by which small firms grow faster than large ones. Gunning and Mengistae (2001) reported a similar relationship between firm size and growth for Ethiopian manufacturing based on firm-level survey data for the 1980s and early 1990s.

On the other hand, firm age seems to have no significant effect on firm growth once initial size has been controlled for. This is unlike Evans (1987) which finds in US manufacturing that old firms grow slower than young firms, controlling for size.

Including additional covariates in the basic firm growth model not only dealt with the selection bias but also revealed interesting results. The growth models estimated in this chapter therefore provide more information on growth performance of Ethiopian firms than those of Gunning and Mengistae (2001), which control only for size, age, ownership and industry effects. The results in table 4.4 show that the productivity term during the first year of observation does not affect subsequent firm growth while market share does. The insignificance of the efficiency term may appear contrary to expectation but should not be surprising, since downsizing is one way of maintaining or improving efficiency, especially

Table 4.4: Firm growth regression (1996–2002)

	I		II		III	
	OLS	**Selection**	**OLS**	**Selection**	**OLS**	**Selection**
Log _ size	-0.0568***	-0.1001***	-0.0992***	-0.1019***	-0.0990***	-0.0896***
	(0.0186)	(0.0290)	(0.0191)	(0.0196)	(0.0199)	(0.0206)
Log _ size2	0.0041**	0.0072***	0.0057***	0.0060***	0.0052***	0.0043**
	(0.0020)	(0.0021)	(0.0019)	(0.0020)	(0.0020)	(0.0021)
Log_ age	-0.0395***	-0.0302**	-0.0440***	-0.0425***	-0.0404***	-0.0462***
	(0.0145)	(0.0147)	(0.0138)	(0.0139)	(0.0138)	(0.0142)
Log_ age2	0.0101***	0.0069*	0.0108***	0.0103***	0.0101***	0.0119***
	(0.0038)	(0.0039)	(0.0036)	(0.0037)	(0.0036)	(0.0038)
Log_ productivity			-0.0022	-0.0017	-0.0007	-0.0025
			(0.0056)	(0.0055)	(0.0056)	(0.0057)
Log_ Market Share			0.0251***	0.0232***	0.0204***	0.0267***
			(0.0053)	(0.0070)	(0.0054)	(0.0077)
Export					0.0378*	0.0389*
					(0.0212)	(0.0213)
Import Competition					-0.0689***	-0.0876***
					(0.0237)	(0.0284)
Foreign Ownership					0.0196	0.0346
					(0.0205)	(0.0243)
Public Enterprise					0.0015	0.0001
					(0.0172)	(0.0170)
Investment					0.0181*	0.0190*
					(0.0104)	(0.0103)
Advertising					0.0287***	0.0303***
					(0.0110)	(0.0109)
Intercept	0.1465***	0.3422***	0.3426***	0.3548***	0.3273***	0.2842***
	(0.0531)	(0.0703)	(0.0622)	(0.0671)	(0.0628)	(0.0704)
		-0.0859***		-0.0118		0.0412
		(0.0221)		(0.0292)		(0.0355)
		-0.8851		-0.1542		0.5195
Wald		129.37		174.36		200.6
Adjusted R2	13.6		21.54		24.5	
Observations	330	597	326	597	326	597
Censored		271		271		271

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

among large firms. This does not necessarily mean that productivity is not relevant to firm growth. It is possible that productivity affects firm growth indirectly through other variables like market share and investment, which happen to significantly increase growth. The significant effect of market share also points to the importance of financial constraints on firm growth in countries like Ethiopia with imperfect financial markets. It is interesting to note that while exposure to high competition from imports does not raise the exit hazard (section 4.3), it significantly restrains business expansion and job creation in the manufacturing sector. This suggests that while competition from imports may induce local firms to become more efficient, their efficiency seems to increase their survival probabilities but not their growth prospects. On the other hand, product differentiation as

Table 4.5: Partial derivatives of firm growth (at the mean)

	I		II		III	
With Respect to	**OLS**	**Selection**	**OLS**	**Selection**	**OLS**	**Selection**
Size	-0.0277***	-0.0482***	-0.0581***	-0.0587***	-0.0615***	-0.0589***
	(0.0052)	(0.0074)	(0.0077)	(0.0076)	(0.0087)	(0.0086)
Age	0.0037	-0.0006	0.0022	0.0017	0.0031	0.0049
	(0.0047)	(0.0051)	(0.0046)	(0.0046)	(0.0045	(0.0048)

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

Table 4.6: Firm growth regression by size category (1996–2002)

	Small and Medium		Large	
	OLS	**Selection**	**OLS**	**Selection**
Log _ size	-0.1610***	-0.1503***	-0.0495	-0.0251
	(0.0612)	(0.0571)	(0.0895)	(0.0838)
Log _ size2	0.0137	0.0128	0.0024	0.0005
	(0.00989)	(0.0091)	(0.0070)	(0.0066)
Log_ age	-0.0593***	-0.0692***	-0.0211	-0.0165
	(0.0198)	(0.0209)	(0.0232)	(0.0213)
Log_ age2	0.0157***	0.0186***	0.0076	0.0067
	(0.0054)	(0.0059)	(0.0054)	(0.0049)
Log_ productivity	0.0036	0.0004	0.0101	0.0069
	(0.0083)	(0.0087)	(0.0091)	(0.0086)
Log_ Market Share	0.0182**	0.0291**	0.0077	0.0136
	(0.0076)	(0.0130)	(0.0106)	(0.0104)
Export	0.0535	0.0549	0.0239	0.0173
	(0.0633)	(0.0638)	(0.0223)	(0.0209)
Import Competition	-0.0367	-0.0737	0.0248	-0.0035
	(0.0332)	(0.0485)	(0.0638)	(0.0603)
Foreign Ownership	0.0085	0.0371	0.0647	0.0445*
	(0.0242)	(0.0374)	(0.0582)	(0.0539)
Public Enterprise	0.0239	0.0080	-0.0429	-0.0446
	(0.0283)	(0.0322)	(0.0289)	(0.0261)
Investment	0.0196	0.0202	-0.0100	-0.0061
	(0.0134)	(0.0133)	(0.0204)	(0.0186)
Advertising	0.0109	0.0141	0.0407**	0.0390**
	(0.0153)	(0.0156)	(0.0172)	(0.0158)
Intercept	0.4350***	0.3841***	0.2147	0.0950
	(0.1068)	(0.1110)	(0.2907)	(0.2668)
λ		0.0588		0.0557
		(0.0561)		(0.0356)
ρ		0.6606		0.9237
Wald X^2		162.45		199.04
Adjusted R^2	22.25		20.10	
No. Observations	205	461	121	136
Censored		256		15

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

proxied by the advertisement dummy promotes firm growth as well as survival time. The results also indicate that exporting firms and firms that invested during the first year of observation managed to grow faster than non-exporters and non-investing firms, although the effect is small and statistically significant only at 10%. This suggests the role of demand in firm growth; with exports being associated with wider world demand and investment reflecting desired output.

Table 4.6 provides regression results estimated separately for large and for small and medium-sized firms. One key observation is that the negative age and size effect holds only for small and medium-sized firms. For large firms, age and size have the correct sign but are not statistically significant, suggesting that Gibrat's Law may hold for samples restricted to large firms. In both subsamples, the selection effect is statistically insignificant, particularly for small and medium-sized firms. For large firms, is significant at the 11% level of significance. Only two variables are statistically significant in the growth regression of large firms: foreign ownership and advertising. This suggests that foreign technological inputs and the introduction of new products or new varieties of existing products (assuming that advertising is relevant to promote new items) play a key role in employment growth among large firms. For small firms, initial age and size are the most important determinants of growth. Small firms with a relatively large initial market share tend to grow faster, perhaps because of the importance of financial constraints for firm growth which are significant only for small and medium-sized firms.

4.5 Conclusions

This chapter examined firm demographics and provided econometric tests of the implications of market selection models. On average, about 20% of firms enter Ethiopian manufacturing industries every year. This rate is comparable to observations from other developing countries, and most of the variation in the rate of entry is across industries rather than over time. Capital intensity and market concentration appear to act as entry barriers. Also as documented in other studies, the rate of entry is highly correlated with the exit rate. Overcoming entry barriers is therefore not a serious problem in sub-Saharan Africa, although the same cannot be said about survival.

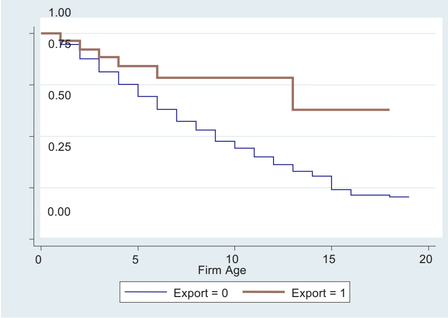
The exit hazard has interesting relations with different covariates. As predicted by theories of industrial evolution, the risk of exit varies inversely with initial size and hence small firms are more likely to exit than larger ones. A non-parametric analysis reveals that the risk of exit for entrants tends to rise during the first four years and starts to decline afterwards showing that firms learn survival skills as they age. This implies that contemporaneous hazard of business failure exhibits a negative duration dependence after a threshold point. Exposure to competition from imports does not seem to raise the risk of firm exit in Ethiopian manufacturing, although it does seem to negatively affect firms' growth prospects. Undertaking investment and having some foreign capital significantly prolong a firm's survival time. Improving the investment climate to increase the proportion of investing firms and to attract foreign direct investment might therefore improve the survival probability of entrants. Chapter 6 elaborates on this point further.

The analysis in this chapter shows that the distribution of growth among surviving firms is not random and not proportional to initial size as stated in Gibrat's Law. Rather, small firms in this sample grew faster than large firms, in conformity with theories of industrial evolution. However, Gibrat's Law seems to hold among large firms, among which growth rate did not depend on initial size. The chapter shows that unobserved selection effects may bias OLS estimates if only size and age are included in the growth regression. While the existence of such a selection effect does not change the overall conclusion that small firms grow faster than larger ones, the selection bias becomes statistically insignificant once other covariates that feature in the survival model are included in the growth regression. The positive age and size effect on firm survival, and the negative size effect on growth, are consistent with an underlying market selection process, which section 4.3 showed to have a positive aggregate impact.

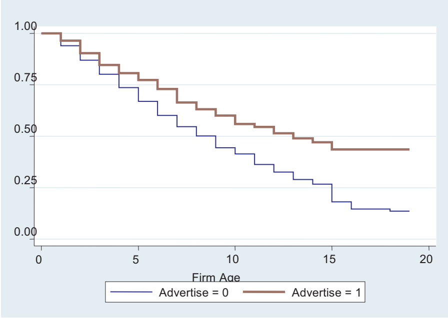
Firm growth is positively associated with market share in Ethiopian manufacturing, particularly among small and medium-sized firms. This suggests the importance of financial constraints in limiting firm growth. Addressing the financial constraints of small firms might therefore possibly strengthen their growth performance and hence their job-creating potential. Productivity seems to be more important for firm survival than for growth, as efficiency gains could be achieved through downsizing. Firms that operate in industries with high competition from imports achieve slower growth rates than those with relatively less import competition. This happens even after controlling for initial differences in firm-level market shares. It suggests that import competition tends to shrink an industry's market share leaving firm-level market shares unchanged, hence exerting an independent effect on firm growth. While this may not necessarily constitute a call for protective trade policy, it does suggest the need to identify the specific competitive challenges facing firms in high-import-competition industries. On the other hand, the presence of foreign capital and product differentiation significantly increase growth rates, particularly among large firms. Attracting foreign direct investment, linking domestic firms with foreign investors and providing technical support for product differentiation are some of the measures that could countervail the growth-dampening effect of import competition.

In conclusion, the analyses in chapters 3 and 4 suggest that policy and institutional problems are not too serious to stifle the proper functioning of markets in sub-Saharan Africa. The manufacturing sector is not short of entrepreneurs willing to try their business ideas. However, survival in the market is not easy and growth, in terms of employment, is largely a small firm phenomenon. The positive contributions of the market selection process for industrial competitiveness notwithstanding, intra-firm productivity has been deteriorating, dragging aggregate productivity down with it. It is therefore imperative to look beyond markets for long-term competitiveness. Chapters 5 and 6 address the role of innovation and investment for industrial competitiveness.

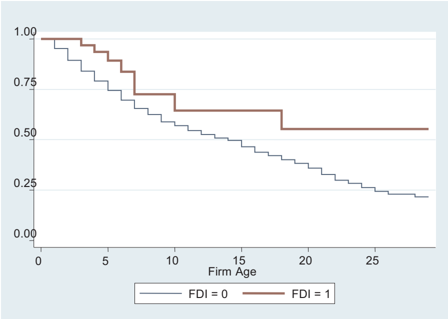
Appendix Chapter 4



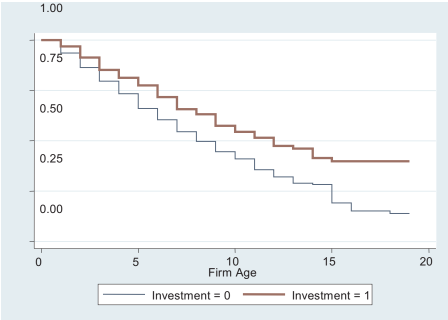
A: Exporting and Non-Exporting Firms



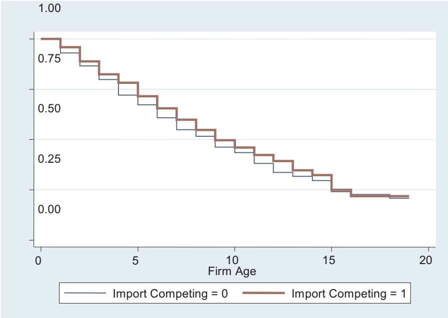
B: Advertising and Non-Advertising Firms



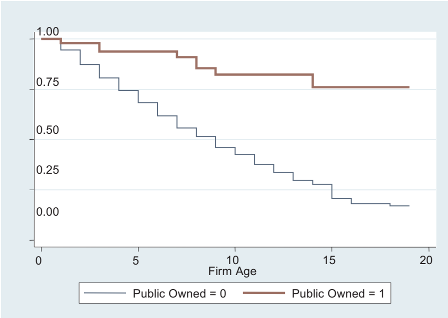
C: Firms With and Without FDI



D: Investing and Non-Investing Firms



E: Firms With High or Low Import Competition



F: Public and Private Enterprises

Figure 4.A1: Kaplan-Meier survival estimates

Notes to Chapter 4

1. An exploratory regression was attempted to understand the determinants of entry. However it did not perform well because of the limited number of observations – entry rate is calculated for nine two-digit industries over five years yielding only 45 observations.
2. A Weibull distribution for duration time takes the form: $F(t) = 1 - \exp(-\gamma t^{\alpha})$ where and are non negative parameters. The hazard function from this distribution will be $\lambda(t) = \gamma \alpha t^{\alpha - 1}$. When $\alpha = 1$ the Weibull reduces to a memoryless function, while $\alpha > 1$ $(\alpha < 1)$ shows positive (negative) duration dependence.
3. The standard errors of the hazard rations are calculated using the delta method. However, the Z-test and p-values corresponding to the hazard ratios (not reported in the tables but represented by asterisks) are calculated from the underlying natural regression coefficients and their standard errors. Although a test based on the hazard ratio and its standard errors would be asymptotically equivalent to that based on a regression coefficient, in real samples a hazard ratio will tend to have a more skewed distribution since it is an exponentiated regression coefficient (Stata Manual, Release 9, 2005).
4. While revenue can also be used as a measure of size and growth, the results are basically similar with models that use employment. Brown et al. (2005) for instance find similar results using both sales and employment as growth indicators for small firms in Romania.
5. The growth equation can be specified as $\ln S_t = \beta_0 + \beta_1 \ln S_{t'} + \beta_2 \ln A_{t'}$ which implies that . In the log linear model, confirms proportional growth while a coefficient less than one rejects Gibrat's Law.

5 Technological Capabilities and Competitive Performance

5.1 Introduction

The preceding two chapters investigated the process of market selection and its contribution to aggregate productivity growth. In brief, the analyses showed considerable heterogeneity among firms within an industry and that market selection is consistent with productivity differences. They also showed that there is a continuous reallocation of resources from less to more efficient producers contributing to industry-level productivity growth. However, the time path of industry-level productivity is heavily influenced by what happens within the boundaries of firms. More specifically, the loss of productivity in Ethiopian manufacturing during the 1996–2002 period was largely driven by a productivity decline within firms. While markets are functioning properly with a positive aggregate effect, the productivity of most firms continued to decline, which indeed is a cause for concern.

"Technological capabilities" refers to the skills, knowledge and experiences that firms acquire through firm-specific learning processes. The literature asserts that technological capabilities determine how effectively a developing country firm can use the modern technology acquired from technology leaders abroad and their ability to upgrade and adapt such technologies (Lall 2001). Since industrial competitiveness requires efficiency growth, not only in the context of existing products but also through the introduction of new and better quality products, understanding the process of technological capability accumulation is an important step in understanding the competitiveness process.

This chapter investigates the accumulation of technological capabilities by Ethiopian manufacturing firms and the effect of such capabilities on post-entry performance. It does so by examining various indicators of technological capabilities for a sample of 127 firms drawn from the population of firms observed in 2002 (the sampling frame). Apart from describing the nature and distribution of technological capabilities in Ethiopian manufacturing, the main objective of the chapter is to relate technical capabilities to two indicators of competitive performance: firm productivity and growth. Although we have no time series data on technological capabilities, the analyses here provide some explanation for the intra-firm productivity decline documented in Chapter 3.

The chapter is organised as follows. The next section elaborates the theoretical underpinnings of the technological capability (TC) approach and how it compares with alternative approaches to technology in the growth literature. It also highlights some of the empirical studies that seek to measure the role of technological capabilities. Section 5.3 then sketches the empirical approach adopted here, which is further elaborated in the respective subsequent sections. Section 5.4 describes the nature and distribution of technological capability indicators and how each relates individually to firm productivity. Section 5.5 employs cluster analysis with the objective of forming typologies of technological capabilities. Section 5.6 relates the accumulation of technological capabilities to firm productivity and growth using regression analyses. Section 5.7 concludes the chapter with a summary of key findings and policy implications.

5.2 The literature on technology and technological capability

The role of technology in economic growth has never been a point of contention. However, the manner in which technological change is incorporated distinguishes one growth theory from another. The simplest is the neoclassical framework, which treats technology as a public good available to all producers at no cost. In this approach, capital accumulation would have only a level effect on per capita income with its growth rate converging to zero in the steady state unless there is exogenous improvement in technology. Technology is the main driver of long-term growth in Solow's (1956) model, although it does not explain how innovation occurs. From a neoclassical perspective, structural aspects of the economy, such as industrial structure and the skill composition of the labour force, do not influence growth. In fact they are inevitable outcomes (byproducts) of growth in per capita income, which leads to a change in the structure of demand for final goods, which in turn dictates factor demand. This framework leaves little room for policy interventions, as the economy achieves the desired structure over time through the smooth functioning of markets.

An important feature of the new growth theories is their introduction of two-way interaction between technology and the domestic economy. In so doing, they attempt to bring to surface the interrelations between the structural aspects of an economy (institutions, infrastructure, market structure, etc.) and the process of innovation, and the effect of such interaction on long-term growth. These models' basic assumption is that innovation, like any other economic activity, responds to economic stimuli – i.e., agents decide to engage in knowledge-generating activities based on market incentives (Aghion and Howitt 1998). Because the Solow-Swan model is a general equilibrium model in a competitive framework, its strict constant returns to factor inputs cannot accommodate rewards for technological effort. Initial attempts to endogenise technology tried to circumvent this by considering technological progress an incidental gain from capital accumulation. This unintended effect, called "learning by doing", remains external to the firm that undertakes the investment while being endogenous at the macro level (Arrow 1962). The so-called AK models are improvements along this line. In these models, knowledge (a form of capital) increases automatically with the accumulation of physical capital and prevents the effect of diminishing returns. In AK models, individual firms do not internalise the effect of capital accumulation on knowledge, i.e., knowledge is unremunerated and non-rival.

Aghion and Howitt (1998) are among the pioneers who introduced endogenous growth models with a reward for innovative activities. The innovative aspect of their model is the effort to incorporate imperfect competition (in the intermediate goods sector) into a general equilibrium growth model. Their model is said to take the middle ground in the accumulation versus innovation debate, in which emphasis is placed either exclusively on the role of capital accumulation for growth even in the long run (Mankew 1995, Jorgenson 1995) or exclusively on innovation as in the Solow (1956) model.

The Aghion-Howitt model shows that an increase in capital intensity complements innovation by raising the equilibrium flow of monopoly rents to innovators. This happens because innovation needs capital and more capital would reduce the equilibrium rental rate. This positive effect of capital intensity on the value of an innovation is the channel through which capital accumulation stimulates innovation. In the steady state, improvement in the productivity of the research sector also increases growth. On the other hand, an increase in the rate of innovation tends to reduce the flow of profits to a monopolist, as the arrival of a new intermediate input would drive the current incumbent out of the market. This market-stilling effect, however, is supposed to be weaker than the growth-enhancing effect. Finally, innovation in the intermediate goods sector leads to growth in per capita income by improving the productivity of the final goods sector, which is assumed to be a price-taking competitive sector. The central point is that capital accumulation stimulates innovation by increasing the equilibrium flow of profit whereas more innovation stimulates capital accumulation through productivity growth. This simultaneous growth prevents the choking effect of diminishing marginal returns and fuels long-run growth in per capita income. This is unlike the simple neoclassical model where long-run growth is driven by technical progress alone regardless of capital accumulation. Even the endogenous growth models of Romer (1990) and Grossman and Helpman (1991) share a similar notion, where the incentive for research and development (R&D) alone drives long-run growth independent of the stock of capital.

However, the Aghion-Howitt model has its own limitations. It does not tackle structural change in an economy, an issue of great importance in understanding the economics of development and competitiveness. An economy is, for instance, always viewed as a scaled-up version of what it was several years ago (Aghion and Hewitt 1998). It also fails to show the organisational structure within which innovations take place. Endogenous growth models assume that research is performed by an individual or collection of individuals; they ignore the reality that most R&D is done within firms. Particularly in developing countries, the learning process at the firm level is critical to understanding technological progress. The theory, moreover, tells us little about the innovative behaviour of firms and assumes that markets determine the rate of technological progress. In such a setting, the role of the state in productivity growth does not go beyond functional interventions, such as the provision of general education and infrastructure, the kinds of interventions that do not interfere with the market's role in the allocation of resources (Evenson and Westphal 1994). Also missing in the model is the role of linkages with global production networks as a source of productivity growth, which is particularly important for developing countries.

Unlike the neoclassical models (new and old), the structuralist approach to economic growth pays utmost attention to structural change and its effect on economic growth. In this approaches, the structure of an economy determines its growth potential, mainly because technology requires certain structural features to play its expected role. By limiting the viable technological options available to domestic producers, structural factors tend to dictate the pace of growth. The other key feature of the structualist approach is its depiction of structural change as a process which is not smooth and definitely not an inevitable byproduct of growth in per capita income. Structural change is possible, but requires skill-specific infrastructure and technological capabilities. Such necessary conditions do not often result from capital accumulation because of pervasive market failure for such resources (Justman and Teubal 1991). From the structuralist perspective the kind of resource reallocation that is of prime importance is that between emerging activities and traditional ones, where markets fail more often than not because of the skill-specific infrastructure that such transitions demand. In the neoclassical framework of analysis, the focus is on the allocation of resources among existing products and producers.

The structuralist perspective evolved, not surprisingly, from empirical observations from both the developed and developing countries. Kuznets (1971), for instance, was the first to note the disproportionately large contribution of new industries to overall economic growth in the United States in the late 19^{th} to mid-20^{th} century. Schumpeter (1934) explained the role of "creative destruction" of obsolete industries in economic growth. In both cases the central issue is the reallocation of resources between existing industries and emerging ones, for which the standard neoclassical analysis of efficient resource allocation among established activities is simply inadequate. Pioneers in development economics have also noted the role of a "Big Push", a lead industry and interdependent industries, in long-term economic growth (Rosenstein Rodan 1943, Nurks 1967, Hirschman 1958, Chenery 1959).

The TC approach is one of the many directions in which the early structuralist literature on technology and industrial growth evolved. The TC approach shares quite a number of assumptions with evolutionary economics regarding the intangible aspects of technology, the costliness of the learning process, the uncertainty surrounding the outcome of learning and the path dependence and bounded rationality of producers in their choice of technology (Nelson and Winter 1982). It differs from the evolutionary approach in that it does not assume that the resources and incentives for innovation already exist in developing countries. Neither is the TC approach about innovation at the technology frontier, as dwelled upon in the evolutionally perspective which focuses on advanced countries. Instead, it centres on developing countries that still rely on technological inputs from advanced countries but make important innovations to use them effectively and adapt them to their specific needs and environment.

While scale economies and vintage effects could perpetuate efficiency differences among firms in an industry, the TC approach looks further into differences in change generating resources within the firm. In that sense, the heterogeneity of firms that it addresses is rather dynamic in nature. Unlike neoclassical growth theories, which treat technology as a separate activity outside of the firm, the TC approach looks at innovation and production activities as interdependent processes within the boundaries of the firm. These nuances represent a useful shift from the traditional presumption – even among development economists – that technological effort and choice in developing countries are subsets of the investment decision. It therefore challenges the assumption that developing country firms have no important role to play with respect to technology, as modern technologies from advanced countries could be obtained through the purchase of machinery and equipment (Evenson and Westphal 1994). This notion evolved from a series of case studies in the 1970s which revealed that learning by doing was not an automatic process.[1] While these studies elaborated on cases of industrial success and failure, they paid insufficient attention to the development of technological capabilities by local firms (Ernst et al. 1998)

It is important to note that the TC approach recognises the importance of macroeconomic stability and the need to correct indiscriminate and indefinite protection as a way forward to industrial competitiveness (Lall 2001). Moreover, there is no presumption in the TC approach that developing country firms, at least at this stage, innovate at the technology frontier. The approach pays more attention to the learning processes that firms need to undertake in order to attain best practice levels of efficiency for a given technology. Access to technology is only part of the competitiveness process. Technology has tacit elements which are not fully transmitted at the time of the purchase of hardware, blueprints and patents. The only way to acquire the hidden attributes is through a firm-specific learning process. Such learning, however, is costly and fraught with uncertainty. The skills, knowledge and experience achieved in this way constitute technological capabilities; they determine the efficiency with which technology is used and most importantly the pace of technological upgrading and adaptation in developing countries (Lall 1992, Bell and Pavitt 2002).

Complex technologies require new skills and take longer to master. Prolonged and costly learning processes imply that developing country firms may refrain from engaging in technologically advanced activities. Even if they do so they may not run them at best practice levels of efficiency. Given the risks attached to technological learning, firms may prefer to stick to low technology, low profit and low risk industries, leading to a low-growth trap.[2] Therefore, even the best designed and implemented adjustment programmes may not lead to industrial competitiveness. The existence of market failure in technological learning suggests that policy interventions could make a difference especially at the small and medium-sized levels (Lall 2001).

The process of learning also tends to be technology specific such that capabilities acquired in one industry do not necessarily enhance competitiveness in another (Stiglitz 1987). The specificity of learning implies a strong tendency toward path dependence in technological progress. The path dependence of learning has both positive and negative connotations. Building learning and technological capabilities in industries that offer greater opportunities for innovation and diversification equips firms with competitive learning advantages, i.e., they can catch up and implement new developments with relative ease. Path dependence could also mean getting stuck with less progressive and low-profit activities, suggesting that there could be multiple equilibria in the process of industrial development among developing countries. Movement into high value-added activities which enjoy growing world demand requires skills and resources that are not readily available in the market.

Empirical studies on the TC approach

The TC approach has played an instrumental role in elucidating the competitiveness debate. The approach perceives competitiveness as a dynamic process requiring more than natural resource endowments. Cross-country comparisons of performance in manufacturing and manufactured exports are a widely used empirical method of understanding the role of technological capabilities. UNIDO (2002) recently published such an attempt to benchmark national competitiveness based on the TC approach. The emphasis is on national success in manufactured exports while achieving a rising level of real income for citizens. UNIDO's *Industrial Development Report 2002/3* introduced such an index to construct a new industrial performance scoreboard based entirely on published country-level data. Four indicators were chosen to construct what it calls the Competitive Industrial Performance (CIP) index that underlies the scoreboard. The four indicators are manufacturing value-added per capita, manufactured exports per capita, the share of medium- and high-technology manufactures in manufacturing value-added and the share of medium- and high-technology manufactures in manufactured exports.[3] UNIDO claims that the CIP is an efficient index which complements the popular indices that are based on the business school approach to competitiveness, i.e. that in the *World Competitiveness Report* of the World Economic Forum (WEF) and the *World Competitiveness*

Yearbook of the International Institute for Management Development (IMD). The idea underlying the CIP is to capture not only the relative importance of manufacturing and manufactured exports, but also the technological composition of what is manufactured and exported so as to reveal inter-country differences in technological capabilities.

UNIDO's *Industrial Development Report 2002/3* goes further to benchmark countries according to some structural factors that are said to determine industrial performance. These factors include skills, R&D expenditure, foreign direct investment, licensing payments abroad and physical infrastructure. These are variables (called "drivers" of industrial growth in the report) for which data is available from published sources for most countries. Apart from a positive correlation among themselves, these factors have been shown to have a statistically significant positive association with the CIP index (UNIDO 2002). The lesson to be learned is that counties that rank high in drivers (technological capabilities) are also countries that manufacture and export technologically advanced commodities. In both the CIP and the individual indices of the drivers of industrial performance, for instance, African countries occupy the bottom ranks. The analysis shows that African countries need to catch up quickly in terms of the drivers of industrial growth and exports if they are to close the technology gap, even with the leaders in the developing world.

Competitiveness has traditionally been defined in terms of differences in unit labour cost. Dissatisfied with the narrow scope of cost-competitiveness, Jan Fagerberg (1988) made one of the earliest attempts to test an econometric model of competitiveness, which includes both price and structural variables. The structural variables he considered include ability to compete in technology (proxied by a weighted average of non-military R&D and external patents) and ability to compete in delivery capacity (proxied by share of gross investment in GDP). Using a panel of 15 OECD countries he found evidence that structural variables play a much more important role in determining cross-country differences in export shares than cost competitiveness. Based on a cross section of 49 developing countries, James and Romijn (1997) also tested the role of structural and incentive variables on technological complexity (as an indicator of competitiveness) of the engineering goods industry. They found that small economies (in terms of market size) can make up for demand-side disadvantages through interventions in the science and education sectors to remain competitive.

Although the TC approach has a strong micro-foundation, most of its empirical studies and policy discussions are carried out at the national level. Furthermore, the competitiveness indices are at the country level and do not reveal the problems and competitive challenges of countries in specific industries let alone the firm-level processes of productivity dynamics and technological learning. Like the competitiveness ranking exercises, the cross-country econometric studies also abstract from industry-specific differences in competitiveness (except James and Romijn). The focus on exports as an indicator of competitiveness also has its limitations as long as the basis of the exports and their technological level are not identified.

Though they do not address technological capabilities directly, a recent body of cross-country research on export and growth has revived the issue of structural transformation through innovation. Evidence from these studies shows that economic growth is underpinned by building capabilities for a wide range of export products rather than specialising in a narrow basket of goods in line with traditional comparative advantage (Imbs and Wacziarg 2003). According to Imbs and Wacziarg, countries diversify as they grow, and specialisation starts only after they reach a relatively high income level (approximately that of Ireland). Most importantly, some sectors, particularly technologically advanced manufacturing, tend to allow more learning and innovation that could sustain growth over the long run (Hausmann et al. 2005, Hausmann and Klinger 2006). Although these ideas are not new to development economists, these studies provide fresh and compelling evidence to support them.

In an effort to show the importance of a country's export mix for economic growth, Hausmann et al. (2005) first calculated a weighted average of the per capita income of countries that export a particular commodity using countries' revealed comparative advantages as weights. Once the average income associated with each export product is calculated (which they refer to as *PRODY*) they then constructed the income level of each country based on (share) weighted average corresponding to the *PRODY* of each of its export items (which they refer to as *EXPY*). Apart from the expected high correlation between *EXPY* and per capita GDP, it is interesting to note that some countries, like China and India, have *EXPY* levels way beyond what could be predicted based on their income levels. The authors also show that current *EXPY* is a statistically significant predictor of future growth after controlling for standard covariates. This indicates that the degree of sophistication of a country's exports has important bearing for its growth potential.

Hausmann and Klinger (2006), on the other hand, examine structural transformation and how it is affected by a country's current composition of exports. They conceive structural transformation as a movement from one tree to another in a forest of products. A country's speed of transformation (or rather the ability of its firms to jump from one tree to the next, more advanced tree) depends on how close the trees are to one another. Their analysis shows that some sectors, for example, the oil industry, tropical products and raw materials, have very specific infrastructure and skill requirements that do not prepare a country to initiate the production of other goods – the forest is sparse. On the other hand, the product space for manufacturing is so dense that firms can easily migrate to a better part of the forest. The ease of migration/transformation is a spillover that cannot be internalised through markets, suggesting the need for deliberate policy interventions that facilitate the accumulation of capabilities by firms in the manufacturing sector. These country-level studies need to be backed by firm-level analyses of technological capabilities for a more complete understanding of competitiveness. Unfortunately, there are few firm-level studies on accumulation of technological capabilities and industrial competitiveness.

Biggs et al. (1995) made an effort to incorporate firm-level learning mechanisms as processes that leads to capability building in a production function for three sub-Saharan African countries, namely, Kenya, Zimbabwe and Ghana. Indicators of technological capabilities included the proportion of workers who participated in training (both internal/ external and formal/informal), share of foreign ownership, a dummy for participation in export markets, and another dummy for technology transfer from abroad. The estimation results indicate that, with the exception of the export dummy, technological capabilities was a statistically significant source of technical efficiency for firms in Zimbabwe and Ghana. For Kenya, none of these variables were significant. Given the difficulty of directly measuring technological capabilities, Biggs et al. (1995) used case studies to back up their regression results.

Based on a sample of 50 Zimbabwean manufacturing firms, Teitle (2000) constructed a technological capability (TC) index (from about nine indicators of technological capabilities) and used this index to explain firm performance in terms of sales per worker and the probability to export. He found the aggregate TC index to have a statistically significant effect both on productivity and exports. In a similar fashion, Wignaraja (2002) used 12 innovative activities to construct a TC index for a sample of 40 garment firms in Mauritius. He used it to explain share of exports in total output (textile is Mauritius' major manufactured export) and found a significant positive effect. Bhaduri and Ray (2004) used relatively advanced indicators of technological capabilities by splitting such capabilities into measures of know-how and know-why. They used R&D outlays as well as research output (such as number of new products and research reports) to explain firm-level export performance in the pharmaceutical and electronics sectors of India. They showed that while direct measures of know-how and know-why as indictors of technological capabilities are not statistically significant in explaining exports, the efficiency with which such capabilities are generated (in terms of know-how and know-why per unit of R&D outlays) is significantly associated with export growth.

Both Wignaraja (2002) and Bhaduri and Ray (2004) studied highly export-oriented industries in Mauritius and India, respectively. Ethiopian manufacturing firms on the other hand predominantly target the domestic market. It will therefore be interesting to examine the role of technological capabilities on firm-level performance in terms of productivity and employment growth in the context of industries not oriented towards the export market.

5.3 Data and methodology

This chapter uses primary data collected through a manufacturing sample survey conducted by the author in Ethiopia from January to April 2004. The sample includes 127 establishments from four industries in the vicinity of Addis Ababa. For details on the sampling procedure refer to Chapter 2 (section 2.3).

The empirical approach in this chapter has three components. Section 5.4 explores the distribution of accumulation of technological capabilities across firm size, age and industry categories. This is often accompanied by bivariate association of total factor productivity (TFP) with indicators of technological capabilities. The TFP is calculated using the production function estimation method explained in Chapter 3 based on a panel data of the population of Ethiopian manufacturing firms. This means that it combines information from two datasets: the sample survey that captures measurements of technological capabilities and the census-based panel data collected by the CSA of Ethiopia. The CSA panel data is suitable for estimating production functions and firm-level TFP, though it contains no information on technological capabilities. Merging the two datasets, therefore, enables us to assess the relationship between innovation and productivity at the firm level. Section 5.5 deploys a cluster analysis in an effort to form a typology of technological capabilities based on the nature of innovative activities engaged in by different groups of firms. The technology clusters are again compared for differences in productivity using the TFP index calculated from the census-based panel data. Section 5.6 tests the implications of the TC approach using regression analysis – we use firm productivity and growth as performance indicators. These models contain individual indicators of technological capabilities as well as an aggregate TC index as explanatory variables. Further discussion of each methodology is provided in the relevant sections.

5.4 The nature and distribution of technological capabilities

5.4.1 Acquisition of foreign technology

Acquisition of modern technology is a critical element of industrial competitiveness in developing countries. Apart from investment in new machinery and equipment, developing country firms can access foreign technology through several channels, including licensing of technologies, technical assistance and employing expatriate staff. The nature of technologies acquired through these different sources is bound to be different. For instance, licenses often relate to product technologies and hence are product-specific in nature, while technical assistance and expatriate staff are often associated with process technologies and tend to be relatively broader in application. The incidence of these technological activities among Ethiopian manufacturing firms sheds some light on the ease at which firms utilise them and also on inter-industry differences in this regard.

Figure 5.1 shows that the three channels for accessing foreign technology are utilised rather sparsely in Ethiopian manufacturing. These three channels are represented by dummy variables that take the value 1 if a firm engages in that activity and 0 otherwise. Less than 10% of the sample firms used licensing to acquire foreign technology. A slightly higher proportion of firms (about 14%) got technical assistance from abroad and nearly 18% of firms employed expatriate staff. There was some overlap among these channels of foreign technology. For instance, 42% of firms that licensed technologies also got technical assistance. The data shows that most expatriates (about 62%) functioned as technicians while one-fourth held managerial positions.

The limited incidence of such disembodied foreign technology sources suggests that most firms rely on technologies embedded in machinery and equipment rather than engaging in a continuous process of improvement and upgrading. Subsequent sections investigate whether such technological activities, limited as their occurrence may be, make any difference in determining the relative efficiency and growth prospects of those firms that undertake them.

Table 5.1 shows an interesting size and industry dimension of foreign technology acquisition. The proportion of firms with technology licenses increases monotonically with firm size; the incidence among large firms is nearly twice as

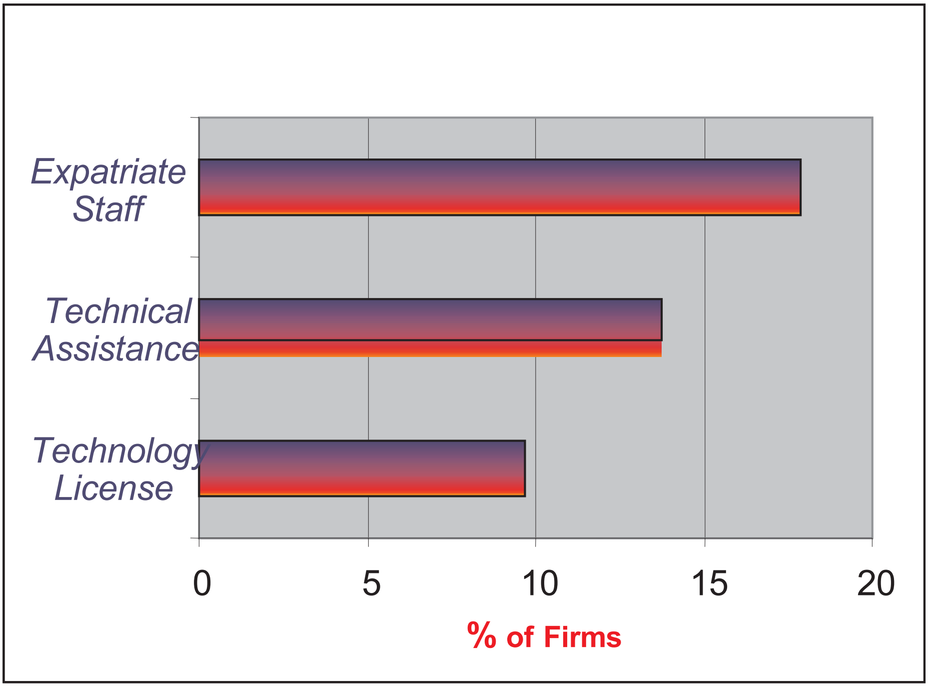


Figure 5.1: Incidence of foreign technology acquisition
Source: Sample survey.

Table 5.1: Foreign technology acquisition by firm size and industry

	Percentage of Firms that Use...		
	Technology License	**Technical Assistance**	**Expatriate Staff**
By Firm Size			
Small	6.8	2.3	11.6
Medium	9.7	29.0	32.3
Large	12.2	14.3	14.3
By Industry			
Textile & Garments	3.4	6.9	13.8
Leather & Footwear	0.0	14.3	10.7
Chemical & Plastics	19.4	11.1	20.0
Metal	12.9	22.6	25.8
Total	9.7	13.7	17.9

Source: Author's computations from sample survey.

high as in small firms. Technical assistance and hiring of expatriate staff as means of acquiring technology are, however, more prevalent among medium-sized firms than in small and even large ones. Overall, medium-sized firms seem to be most active in acquiring foreign technology. This reflects perhaps the tendency among large firms to rely more on their economies of scale, making them less keen than medium-sized firms to acquire other sources of productivity growth.

In terms of industries, technological activities are more prevalent in the relatively technologically advanced industries (chemicals and plastics, and metal) compared to the low-technology industries (textile and garments, and leather and footwear). Close to 20% of firms in the chemical industry have foreign technology licenses; the highest such percentage among the four industries. In the metal industry, firms tended to resort mainly to technical assistance and hiring of expatriate staff. The latter points to the different technological capabilities that may be needed in different industries. Obviously the chemical industry needs more process technologies while the metal industry may require mainly technical skills, gained either through technical assistance or by employing foreign nationals.

5.4.2 Initial and post-entry investments

Initial investment

For most developing countries, investment in machinery and equipment remains an important channel for acquiring modern technology. Firms can enter an industry with new or used machinery and equipment or a mixture thereof. This composition is explored here both for initial investment and for subsequent expansions in capacity. Similarly, firms can choose to import machines from abroad or purchase them locally. The purpose of this exploration is to provide an indication of the age and quality of machines at entry into the market and its implications for productivity. Firms that enter with used machines and never make additional investments thereafter would be expected to be less competitive than counterparts that start with and continue to import new machines.

About 53% of firms entered an industry with new machinery and equipment while 30% started with a mixture of new and used machinery. Less than 20% of firms joined the sector with only used machinery. In terms of size, a bit more than 60% of medium-sized and large firms joined their respective industries with new machines, while only 37% of small firms did so. This suggests that the familiar positive association between firm size and efficiency is not only a scale effect but partly traceable to differences in machine age at entry.

A similar comparison was made for different subsamples of firms established under different policy regimes in Ethiopia. The results show a declining trend in the share of firms entering with new machines. During the imperial regime (before 1974) and the military regime (1974 to 1991) about 57% of firms had new machines upon their establishment. This proportion fell to 47% for firms established under the reformist government since 1991. Moreover, about 60% of firms established before 1991 imported all of their machines from abroad, while for firms established since 1991 this share is just below 40%.[4] This implies that the average age of machines upon entry has risen since 1991, and the proportion of imported machines has declined compared to the previous two regimes. However, one should be cautious about the selection effect here. For firms that entered before 1991, the proportions are calculated based on firms that survived over a long period of time. The high proportion of entry with new machines among older firms could be the result of the exit of firms that entered with used machines. Similarly, the relatively small proportion of firms among recent entrants that started with new, imported machines is partly because the selection process is not yet complete. In the absence of information on actual machine age and procurement source at entry, the above interpretations should be taken with caution.

Given the liberalised trade policy and relatively better availability of foreign exchange in the current reformist regime, one would expect to see a growing proportion of entrants joining industries with imported new machines. The selection problem notwithstanding, this has not been the case. This has to do with changes in the macroeconomic environment. The nominal exchange rate in Ethiopia was fixed at 2.07 Birr/USD for a large part of the imperial regime and throughout the military regime. The local currency was therefore highly overvalued for a long period of time. Devaluation of the exchange rate by more than 142% in 1992 and the subsequent introduction of a market-determined exchange rate regime did away with overvaluation of the currency. This makes imports dearer now than in the previous two regimes.[5] Moreover, the financial sector has been to some extent deregulated, resulting in higher interest rates than in the pre-reform periods.

Such reform measures have increased the average cost of capital, and firms seem to be responding by resorting to used machines instead of importing new ones. The mean US dollar value of initial (entry level) investment has accordingly declined from US $2.15 million before 1974, to US $1.59 million during 1974–1991 and further to US $1.36 million after 1991.

Figure 5.2 reveals that entering with new machinery is positively associated with subsequent level of productivity. On average, firms that began with new machinery did better than those that began with a mixture of new and used machines, which in turn did slightly better than those that started with only used machines. Among firms that entered with new machines or a mixture of new and used, productivity was higher for those firms that relied fully on imported machines compared to those which mixed imported machines with locally acquired ones. The productivity of firms that began with machines fully purchased locally (no matter whether old or new) was far lower than that of firms that imported most or all of their machines from abroad – but the former account for less than 10% of the sample firms. The difference in productivity is likely due to the wide range of choices that firms have when they import machines from abroad coupled with the technical assistance and other complementary services provided by suppliers.[6]

The upshot of these findings is that entry with imported new machines tends to enhance subsequent productivity level. This is not surprising, since machine

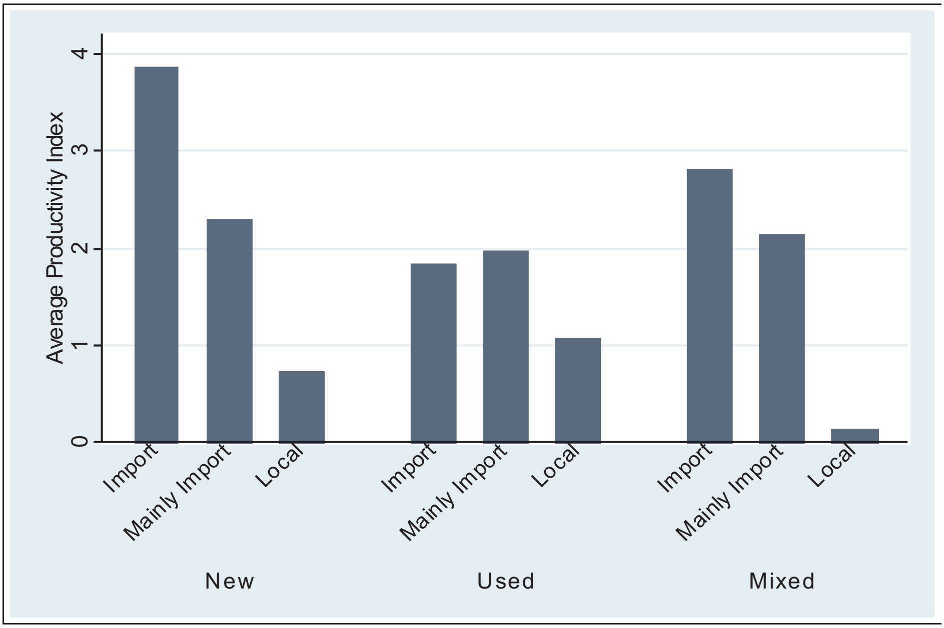


Figure 5.2: Average productivity of firms by machine age and source

Source: CSA manufacturing census and sample survey.

breakdown, which increases with age, leads to repeated interruption of production and high maintenance costs. It also suggests that the current macroeconomic environment has made it more difficult for entrants to start off with imported new machines. Any loss of productivity as a result of acquiring older and perhaps less suitable machines compromises the competitiveness of young firms. This implies that the need for other technological capabilities that would enhance efficiency is more pressing now than ever before.

Post-entry investment

Entry status should not necessarily set the entire path of firm-level productivity. Firms can retool and expand through additional investment after entry. Table 5.2 and the subsequent paragraphs examine post-entry investment by firm size and age.

Table 5.2 shows the size dimension of major investment after entry. About 60% of small firms made expansionary investments after their establishment, and this rate is about 81% among medium-sized firms and 89% among large firms. Large firms are therefore more likely to have made major investments after entry. The table also points to some non-linearity in the probability of undertaking major investment with respect to age. About 84% of firms that were established before 1991 had undertaken major investments since their establishment, a proportion that falls to 68% among younger firms, i.e. those established since 1991. The probability of making major investment is thus relatively low among young firms, thereafter rising to a peak and then ebbing among older firms.

This pattern matches the survival and growth patterns of firms explained by the regression models in Chapter 4. The risk of failure is higher among young firms, making them less inclined to undertake major expansion. After passing the four- or five-year threshold at which the risk of failure reaches its peak, firms become more certain of their relative efficiencies thereby increasing the desirability of investment. As firms age, they achieve their optimal size and the desire for major expansion begins to decline. This phenomenon is explored further with a non-parametric (*lowess)* regression of the fraction of firms that made major expansion against firm age. The *lowess* regression curve in figure 5.3 supports the previous assertion and reveals another twist in the non-linear relationship. Instead of declining continuously after reaching a peak, the proportion of expanding firms among older firms starts to rise once more, albeit very gently.

Table 5.2: Share of firms implementing major expansion after entry

Firm Size	**Share of Expanding Firms (%)**	**Entry Period**	**Share of Expanding Firms (%)**
Small	60.5	Before 1974	83.3
Medium	80.7	1974–1991	84.4
Large	88.9	1991–2002	68.5
All Firms	76.5	All Periods	76.5

Source: Author’s computations based on sample survey.

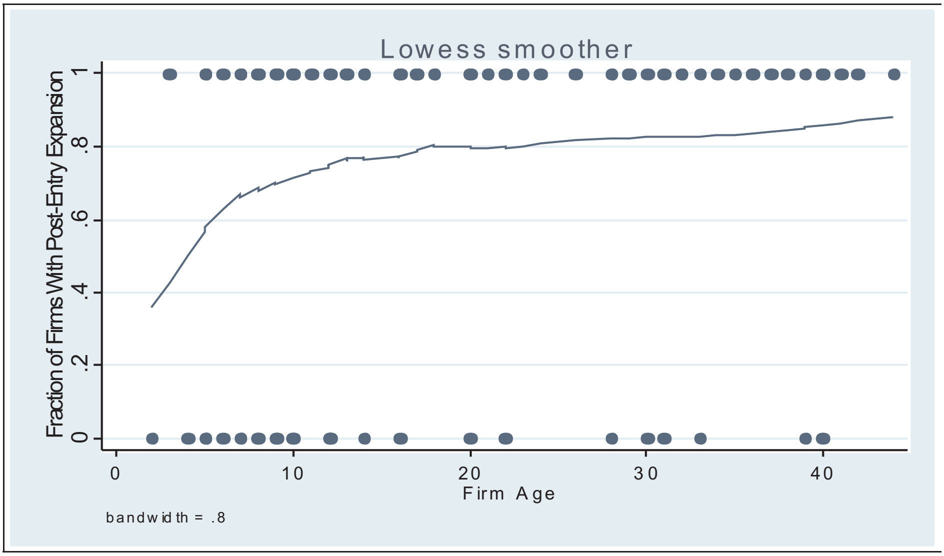


Figure 5.3: Lowess regression of firm age and probability of business expansion
Source: Author's sample survey.

5.4.3 Post-entry investment and demand for skilled labour

Primary purpose of expansion and skill demand

An implication of the TC approach for competitiveness is that investment in new machinery and equipment, inasmuch as it embodies new technology, could be constrained by the demand for skilled labour that it entails. This section explores the importance of this linkage in Ethiopian manufacturing.

For about one-third of firms which undertook major investment after entry, introducing a new product was their primary purpose. About one-quarter (22%) invested mainly for the sake of adding capacity for an existing product. Another 20% invested primarily to diversify the variety of the same product. Figures 5.4 and 5.5 summarise firm size differences in the primary purpose of investment.

The figures reveal an interesting connection between firm size and the main purpose of investment. Figure 5.4 shows that the fraction of firms investing mainly to increase capacity for an existing product is much higher among small firms. Relatively few medium-sized and large firms invested for this purpose. It seems that linear growth (along the same product line) is a feature more prevalent among small firms. Figure 5.5 on the other hand reports the share of firms within each size category whose major purpose in post-entry investment was to introduce a new product or a new variety of an existing product. In this case, medium-sized firms take the lead; major expansion in two-thirds of medium-sized firms is associated with a new product or a new variety. This proportion falls to 50% among large firms and slightly above 40% for small firms. This suggests that medium-sized firms are more innovative than small and even large firms, whereas for small firms the top priority of investment is linear growth. This reflects on the one hand the relative flexibility that medium-sized firms enjoy in introducing a new product compared to large firms and their scale advantage over small firms on the other.

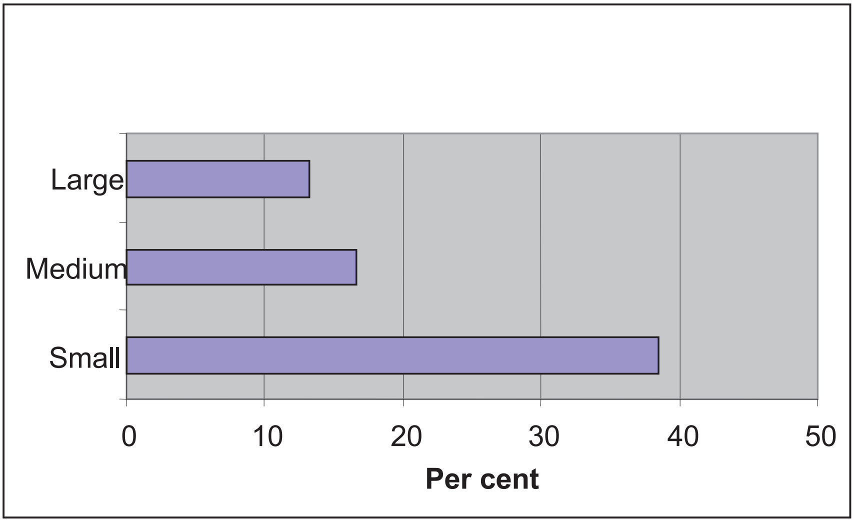


Figure 5.4: Fraction of firms investing mainly to add capacity
Source: Author's sample survey.

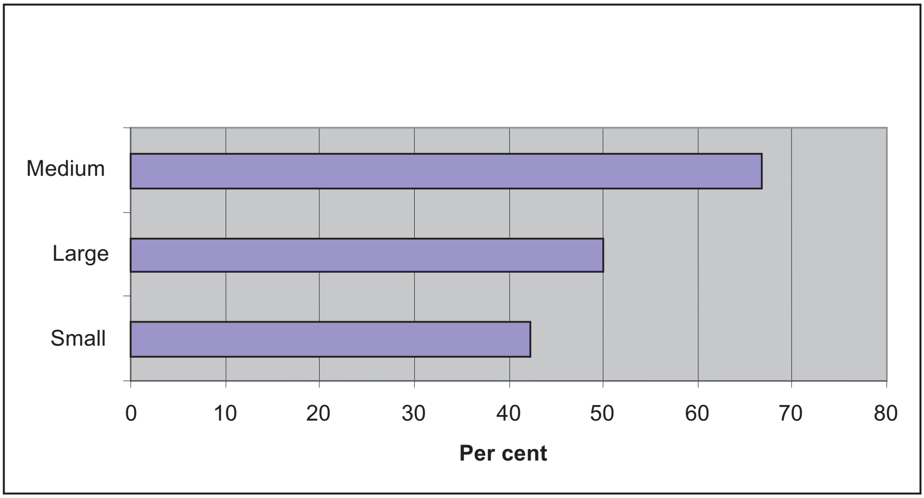


Figure 5.5: Fraction of firms investing primarily to introduce a new product or new variety
Source: Author's sample survey.

Accordingly, if industrial progress occurs principally through new products or new varieties (perhaps better quality) of products, a focus on medium-sized and large firms would be a preferred growth strategy. On the other hand, if producing more of existing products takes industries to a higher growth path, the strategy may have to be slanted to promote small enterprises. The dominant pattern in the global economy, however, is growth driven by new and better quality products that replace old ones (Stokey 1991). In this scenario developing countries would do better to focus on medium-sized and large firms that have both the flexibility to adapt to changes and a minimum efficient scale to benefit from innovative activities. However, medium-sized firms have been described as the "missing middle" in the bimodal size distribution of manufacturing firms for most developing countries, which are dominated by small and micro-enterprises at one end of the spectrum and a small hump of large firms at the other end (Tybout 2000). This feature does not however hold in Ethiopian manufacturing, as the size distribution of firms is skewed to the right with no bimodality.

The TC approach to industrial competitiveness argues that the transfer of technology is not completed with the transfer of machines or blueprints. This is because tacit elements underlie most technologies, particularly advanced ones. Such tacit elements need to be acquired through a firm-specific learning process and reside in the skills, knowledge and experiences of a firm, which we referred to collectively as technological capabilities. It is the effective combination of such unobserved components with the embodied/coded component of technology that leads to the best practice level of efficiency in a particular industry.

While section 5.6 provides a more formal test of this proposition, this section presents a preliminary test by reviewing the relationship between new investment and demand for new skills. About one-third of manufacturing firms needed new skills in association with their major investment after entry. It is interesting to note that this proportion varies considerably depending on the major purpose of investment. Figure 5.6 shows that among firms whose primary purpose of additional investment was introducing a new product, the proportion of firms that required new skills rises to 50%. This is followed by firms whose primary purpose of investment was to improve process efficiency, where 43% required new skills. Among firms that invested mainly to increase capacity for an existing product, only 22% required additional skills. Demand for extra skills is therefore partly dependent on the major purpose of investment. The assumptions of the TC approach thus seem to be supported in this sample, and the findings show new capabilities to be particularly relevant for firms that plan to acquire advanced technologies or introduce new products and processes.

If introducing a new product and process requires new skills that firms do not already possess, then investment in new machinery or equipment would not necessarily make firms more efficient. Running machines at best practice level of efficiency requires new skills and if these skills are not available in the market firms may refrain from investing in new products and processes. In the long run,

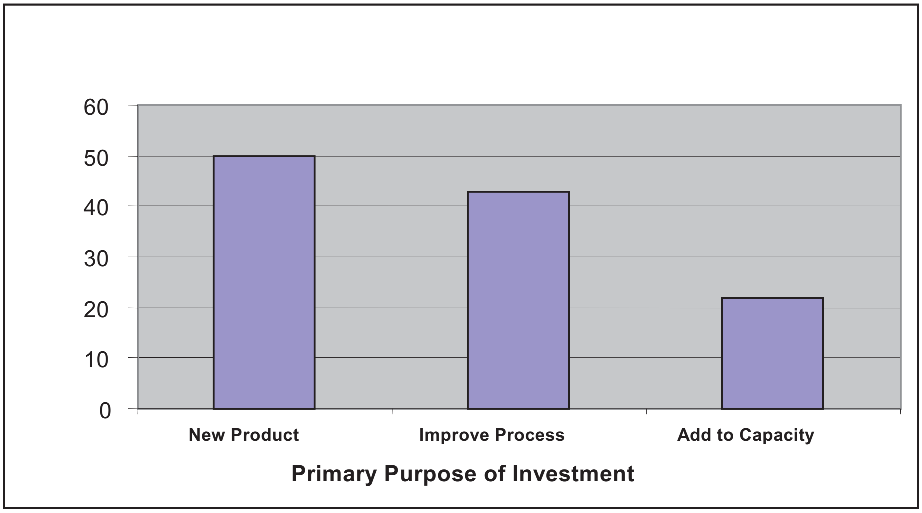


Figure 5.6: Share of firms that needed new skills after investment
Source: Author's sample survey.

the process of industrial development will therefore be determined by the speed at which firms can build technological capabilities. However, the fact that new investment requires new skills does not necessarily constitute a constraint. This depends on how serious the skill shortages are in a particular market.

The survey shows that overall 37% of the sample firms experienced skill shortages in the period under study. This proportion differs significantly between firms making expansionary investments and those not doing so. Among the latter, only 31% experienced skill shortages while among the former the share is 39%. More important is the connection between the purpose of investment and the skill shortage experienced. For firms that invested mainly to improve the process of production, the probability of experiencing a skill shortage was about 60% followed by firms that invested mainly to introduce a new product at 44%. If investment was primarily for adding capacity, the probability of encountering skill shortages falls to 26%. Technical skills are therefore a critical component of industrial growth and competitiveness.

To further pin down this issue, firms were asked if they had hard-to-fill vacancies or vacancies that had not yet been filled though they were open for a long time. About 50% of firms that faced skill shortages had experienced difficulty in filling vacancies. About 48% of these still had vacancies that were proving hard to fill. All of the evidence from the survey points to a critical role played by skill shortages, especially for firms attempting to grow by introducing new products or new varieties of existing products. These results are consistent with the findings of Haskel and Martin (2001) for the United Kingdom.

Skilled labour and total factor productivity

We saw that certain kinds of investment require additional skills and firms that undertake such investment are likely to face skill shortages. Does the skill level of employees affect the competitiveness of firms and industries? In other words, do firms improve their relative productivity by employing skilled labour or by improving the skill levels of their employees through training? Numerous econometric estimates of earnings functions have found significant individual rewards to human capital (education and experience) in the labour market. While this indicates a relationship between education and an individual worker's productivity, we would like to find out if employing skilled workers enhances the productivity of firms as one would normally expect. To that end, this section provides a review of managers' perceptions of the relative skill levels and comparative ranking of their employees in their respective industries. The ranking is then compared with actual TFP estimates for 2002. The firm-level TFP is obtained independently, from a production function estimated on census-based panel data for the period 1996 to 2002. The estimation procedure controls for the simultaneity problem following the method suggested by Levinsohn and Petrin (2003). Figure 5.7 presents this comparison.

The horizontal line in figure 5.7 indicates the average TFP index in logarithms which is equal to zero. The figure indicates a number of facts. Firms which believe they have employees whose skills are at the industry average (this group also includes a few firms that consider their employees' skills below average) have a relatively imprecise perception of their relative efficiency. The median firm in this group has a productivity level very close to the mean industry TFP. This implies that there are nearly as many firms above the mean industry practice as there are below. Theories of market selection suggest that this would happen if most firms in this group are small entrants that have yet to discover their true relative efficiencies. On the other hand, the lower quartile of firms which believe they have *highly skilled* employees coincides with the industry mean productivity. This suggests that 75% of firms in this category have productivity levels higher than the industry mean. For firms considering their employees *very highly skilled*, the lower quartile is well above the industry mean and the median is close to the upper quartile, clearly showing that firms in this group do indeed have higher levels of productivity. It is interesting to note that firms' perceptions of their relative efficiency is pretty consistent with their actual relative efficiency, although firms at the lower end of the distribution tend to have more imprecise perceptions. It is also clear that skilled labour is a key component of relative efficiency. Later on we use regression analysis to cement this bivariate association between skills and productivity.

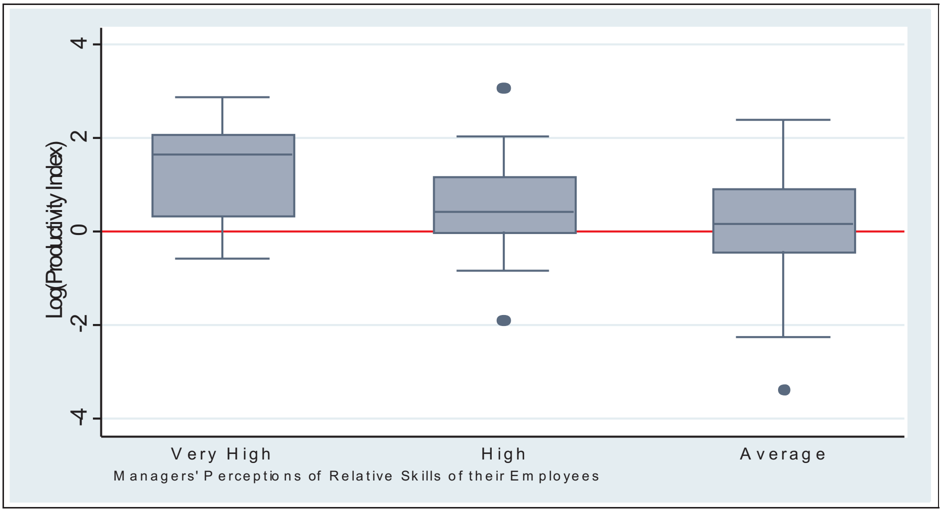


Figure 5.7: Perceived relative skills of workers and firm productivity
Source: CSA manufacturing census and author's sample survey.

Employee training

It has been shown that skilled labour is positively associated with firm-level productivity, while firms that invest for the sake of introducing a new product or process are more likely to face skill shortages than firms that invest only to expand capacity. Training of workers is an obvious way to build technological capabilities. Studies in developed countries show considerable variation among firms and industries in the incidence of training. Part of the reason is the reluctance of firms to train workers due to high employee turnover. In some cases, the act of training itself increases the probability of employee turnover, as other enterprises poach trained workers. Markets therefore may fail to provide an optimal amount of training (Biggs 1995).

Heterogeneity in the incidence of training also arises as the cost of training is likely to be very high for small and medium-sized enterprises because they cannot spread training costs over a large output volume. The cost in terms of output forgone as a result of training is also higher for small firms. They are therefore less likely to invest or might invest less in training employees. Firm investment in training is also a function of their technological complexity. Firms in technologically advanced industries tend to invest more in training than firms in low technology industries, where informal training within the firm would suffice (Aw and Batra 1998).

Although skilled labour appears to be important for firm productivity and expansion in Ethiopian manufacturing, only 11% of the sample firms provide any formal training to their employees. As might be expected, training is particularly low among small and medium-sized firms, for which the incidence of formal training is less than 10%. Even among large firms, the proportion of firms that provide formal training is only 16%. For firms that do conduct formal training, their average level of efficiency is significantly higher than that for those providing no formal training to their employees.

Given the generally low level of human capital in the Ethiopian economy as a whole, there is a clear market failure in the supply of one of the critical inputs for industrial growth and competitiveness. It would therefore appear naive to expect competitive industries to emerge in poor economies by relying on market forces alone. Particularly in countries where the coverage and quality of formal education is very low, firms must invest more to upgrade the skills of their employees to a globally competitive level. This observation is in line with the analysis of Biggs (1995), who argued that the predominance in African manufacturing of small firms with low skill levels implies that the required level of training is huge and beyond the capacity of individual firms.

In terms of industries, the highest incidence of training occurs in the leather and footwear industry followed by the metal industry at 18% and 13%, respectively. The comparable share is at best 10% in the textile and chemical industries. This observation does not fit nicely with the theoretical expectation that the incidence of training would be higher in technologically advanced industries, because of the expected skill shortages. Rather, it reflects the distribution of existing training facilities in the country which is inclined toward the leather and metal industries. The Ethiopian government recently established the Leather and Leather Products Technology Institute with the support of the Italian government to provide training and technical support in this industry. The Agricultural Development-Led Industrialisation (ADLI) strategy of the current Ethiopian government also identifies leather and leather products as a strategic industry.

5.4.4 Upgrading product quality

Do firms consciously pursue quality? In other words is the pursuit of quality associated with the relative efficiency of firms in an industry? This question is important to ask because if firms pursue quality consciously, they would engage in technological activities aimed at upgrading product quality only if such efforts enhance their competitiveness and market position. Obviously it is difficult if not impossible to gauge quality, particularly when industries are as broadly defined as in this study. In the absence of an objective measure of product quality, managers were asked their perception of the relative quality of their products. Figure 5.8 summarises the responses to this question and compares the quality ranking with the average TFP of firms computed independently as discussed earlier.

Although the range of quality rankings in the questionnaire spans from "very high" to "below average", none of the firms considered their product quality to be below average. This tendency to overestimate relative product quality notwith-

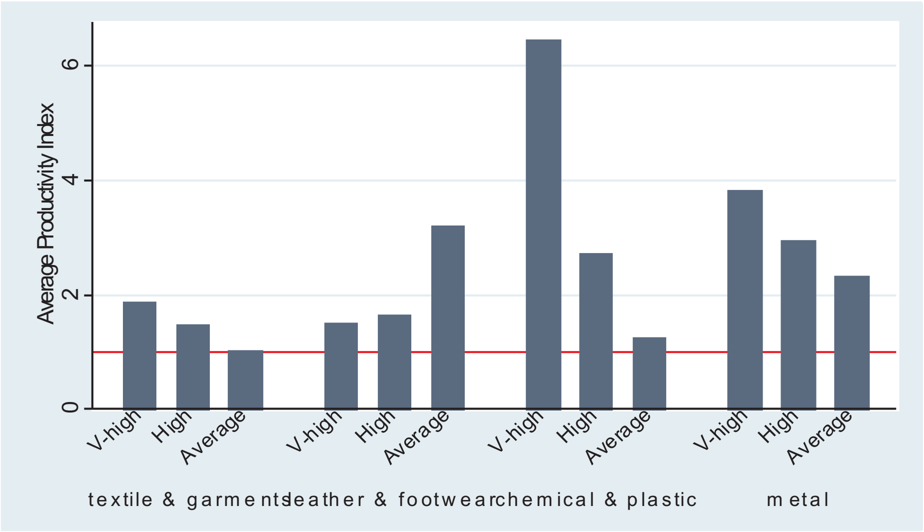


Figure 5.8: Perceived product quality and firm productivity

Source: CSA manufacturing census and author's sample survey.

standing, there is a positive association between (perceived) product quality and TFP in all industries except leather and footwear. Firms that target the high-quality segment of the market are highly productive, and the productivity index declines steadily as quality declines from very high to the industry average. This suggests that upgrading product quality is an important dimension of competitiveness and that industrial progress will depend, among other things, on the availability of economically viable avenues of upgrading for local firms.

In the leather and footwear industry, firms at the top end of the quality spectrum appear to be least efficient, while firms that produce at the industry average are highly productive. Although this appears to be an anomaly, it is not difficult to imagine conditions under which this could happen. Manufacturing high-quality products requires additional outlays, including investments in physical and human capital. While these would increase the cost of production there is no guarantee that prices would rise in commensurate proportions. In such instances, a disparity would arise between building technological capability and productivity. The leather industry is also the only industry in Ethiopian manufacturing with a strong export orientation. For developing country firms aiming at export markets, maintaining product quality is imperative to stay in business, although such firms face uncertain and often unfavourable export prices.

The survey asked firms what was the most important source of upgrading product quality. Firms were given eight choices, which were subsequently collapsed into four sources. The first is *imitation*, which includes either imitation of leading local firms or of imports. In either case the firm looks at products within the domestic market and attempts to emulate new ideas, designs, etc. This is supposedly less costly for the firm doing the replication but costly for the innovative firms. The second source is *importing* new designs and technologies from abroad. In this case a firm looks outside of the domestic market for upgrading, including to suppliers, foreign buyers and other firms that provide technologies. This requires relatively advanced capabilities to locate relevant sources in the global market and also to establish linkages, not to mention the costs involved. Upgrading is also possible by responding to customer suggestions and feedback combined with *in-house* expertise. Depending on the nature of the product this may require systematic gathering of customer opinions and skilled labour that translates these ideas into product and process features.

Table 5.3 shows that about half of the medium-sized and large firms depend on importing new designs and technologies to upgrade product quality. At 38.5%, this is also the most important source of upgrading for the entire sample. Most small firms (44%), however, upgrade product quality in response to customer suggestions coupled with in-house expertise. This supports the often-heard claim that small firms are more likely than larger ones to specialise in niche markets and that their existence hinges on meeting the specific requirements of their customers. It also underlines the limited financial ability of small firms to import new designs and ideas from abroad. That is why for another 28% of small firms the most important source of upgrading is imitating leading local firms or imported products. Among medium-sized and large firms, close to 30% depend primarily on customer suggestions and in-house expertise. For the manufacturing sector overall, interaction between customers and in-house expertise is, second to imports, a primary source of upgrading. Large and medium-sized firms imitate each other or imitate imports as well. However, imitation is a primary source of upgrading for only about one-fourth of them, ranking third as a primary source of upgrading product quality.

Firms' perceptions of product quality are also related to their sources of upgrading. Half of the firms that perceive themselves as manufacturing "very high" quality products, for instance, rely on imported designs and technologies, while 30% combine customer suggestions with in-house expertise. For those with "high" quality products the majority (45.5%) rely on in-house expertise followed by imports at 36.7%. For firms with "average" quality of output close to 40% rely on imitation and another 30% on in-house expertise. In the current order of ef-

Table 5.3: Major sources of upgrading product quality (per cent)

	Imitation	Importing	In-house	Other	Total
Small	27.9	18.6	44.2	9.3	100
Medium	18.8	51.1	28.1	0.0	100
Large	21.3	46.8	27.7	4.3	100
Total	23.0	38.5	33.6	4.9	100

Source: Author's sample survey.

fectiveness of different sources of upgrading, importing designs and technologies from abroad comes first, followed by in-house expertise and finally imitation.

5.4.5 Project appraisal and technical adaptation

Ability to choose viable investment projects is recognised as a key capability in the literature on technological capabilities. Most firms (84%) in this sample undertake project appraisals before making major expansions. Particularly among those firms that invest to introduce new products or varieties, no less than 90% undertake project appraisal studies, which is higher that the 73% share among firms that invest for capacity growth for the same product line. In terms of size, about 70% of small firms do such appraisal studies, which increases to about 80% and 100% among medium-sized and large firms, respectively. Nearly 50% of the appraisal work is done by local consultants while some 40% is done by in-house experts. The remaining 10% is done by foreign consulting firms, though only large firms avail of this option. Small firms rely on in-house expertise for appraisals, reflecting the rather informal or less formal nature of the appraisal work for firms in this category rather than the existence of sophisticated appraisal capabilities within small firms.

Developing country firms undertake technical adaptation of machinery and equipment in response to specific needs and constraints. Such efforts require relatively advanced technical capabilities and reflect firms' "know-why" in addition to "know-how" of the technologies embedded in imported machines. In this sample of Ethiopian manufacturing firms, about 41% had undertaken technical adaptation – a proportion far lower than that of investment appraisal (investment capabilities). About 70% of small firms, 60% of medium-sized firms and 50% of large firms had undertaken no technical adaptation since entry. This reveals the relative scarcity of capabilities to modify and adapt machines to specific situations. Although very few firms answered affirmative to this question (only 35), the most frequent reason cited for technical adaptation was the need to reduce maintenance requirements. Reducing the need for skilled operators is the second most important reason for adaptation. Other reasons for adaptation, like adapting to local inputs, reducing the production lot, reducing speed and using a different energy source, were not very important. This indicates that the technical adaptation undertaken by Ethiopian firms is not at a level where it can be considered an improvement on existing technologies. Rather, it aims to economise on maintenance outlays and the need for highly skilled operators. These are interrelated constraints that emanate from the lack of advanced technical capabilities in the market, even to operate machines at the level of efficiency and technical detail at which they were imported.

The large and medium-sized firms that had adapted machinery relied primarily on equipment suppliers (40% to 50%) and on local consulting engineers (20% to 25%) to carry out the technical adaptation. This suggests that the capabilities for adaptation do not exist within most firms. Only 37% of large firms did the technical adaptation using in-house expertise. Although 63% of small firms reported having used in-house expertise for technical adaptation this most likely reflects the simplicity of the adaptation they undertook rather than their possessing advanced skills that do not exist in medium-sized and large firms.

5.5 Typology of technological capabilities

The literature on technological capabilities suggests several typologies of capabilities depending either on the level of advancement or on the functions of the capabilities. For instance, a familiar and broad categorisation distinguishes between know-how and know-why. Another approach is to divide capabilities into investment, production and process capabilities (Lall 1990). While such typologies are useful, categorisation has largely been ad hoc, with no clear empirical evidence in favour or against.

This section uses cluster analysis to explore whether certain groups of firms tend to specialise in building certain types of capabilities. In a situation where the incidence of technological capability building is very small, firms may choose to accumulate only one or two capabilities. If such a pattern could be found, it could be used to identify the characteristics of firms that find certain types of technological capabilities attractive and to learn whether different capabilities have different impacts on firm performance.

5.5.1 Cluster analysis

Cluster analysis falls within the category of exploratory data analysis marked by the absence of formal hypothesis testing using the familiar t or F statistic. The advantage is that it permits the data "to speak for itself", largely free of theoretical imposition and restriction. It does so by allowing individual observations in a sample to form groups on the basis of simple distance/dissimilarity rules. Such liberty from theoretical restriction is, however, compromised by the wide-ranging rules for cluster formation.

The two most commonly used clustering methods are hierarchical and partition clustering. Hierarchical clustering forms a hierarchy of clustered observations using agglomeration or divisive methods. In agglomerative hierarchical clustering, each observation is initially considered as a separate group (i.e., N groups each with one observation). Clustering begins by combining the closest two observations, and this process continues until all observations belong – through a hierarchy of groups – to a single group. Divisive hierarchical clustering, on the other hand, begins by considering all firms as belonging to one group and forms groups by splitting them repeatedly until all observations are in their own separate groups.

Unlike hierarchical clustering, partition clustering forms clusters in such a way that the groups formed are non-overlapping. The user specifies the number of clusters to be formed and each observation is assigned to a group whose mean or median is closest. A new mean/median is calculated after each round of group assignment, and the reallocation of observations to different groups continues until no observation changes groups. This chapter uses partition clustering, which utilises the cluster mean for comparison. This method is referred to as *Kmeans* clustering.

Kmeans clustering can be carried out for both continuous and binary variables. Since the technological capability indicators in the survey are mainly dummy variables, similarity/dissimilarity measures available in STATA were used for the binary variables. The similarity between two observations was measured based on the four values from the cross-tabulation of any two observations:

In Table 5.4 'a' represents the number of variables in which observations *i* and *j* both have ones, while 'd' represents the number of variables in which observations *i* and *j* both have zeros. Cases 'b' and 'c' represent the number of variables in which one of the observations has a one and the other a zero. There are a many (about 14) measures of similarity based on the preceding table. However, only four of them are applied here to check the sensitivity of the resulting clusters to differences in the utilised similarity coefficient.

The first method used here is the *matching (M)* binary similarity coefficient, which shows the proportion of matches between two observations:

$$M = \frac{a+d}{a+b+c+d}$$

The second is the *Sneath* binary similarity coefficient, which is given by the following:

$$S = \frac{2(a+d)}{2(a+d)+(b+c)}$$

The Sneath (*S*) coefficient is similar to the simple matching coefficient except for its giving double weight to matches.

Table 5.4: Similarity measure for binary data

Observation *i*		Observation *j*	
		1	0
	1	***a***	***b***
	0	***c***	***d***

Source: Stata Manual Version 9, cluster analysis.

The third measure used is the *Anderberg (A)* binary similarity coefficient, given as follows:

$$A = \left(\frac{a}{a+b} + \frac{a}{a+c} + \frac{d}{c+d} + \frac{d}{b+d} \right) \Big/ 4$$

Finally the *Kulczynski(K)* binary similarity coefficient is given as follows:

$$K = \left(\frac{a}{a+b} + \frac{a}{a+c} \right) \Big/ 2$$

The clustering of firms was carried out using eight indicators of technological capability:

- *Technology licensing.* This variable takes the value 1 if a firm had a technology license with a foreign firm in the previous year and 0 otherwise.
- *Technical assistance.* This variable takes the value 1 if a firm had technical assistance from abroad in the previous year and 0 otherwise.
- *Expatriate staff.* This variable takes the value 1 if a firm had expatriate staff in the previous year and 0 otherwise.
- *Employee training.* This variable takes the value 1 if a firm provided formal training to its employees within or outside the firm during the previous year and 0 otherwise.
- *Quality oriented.* This variable takes the value 1 if a firm (based on the manager's perception) produces high or very high quality goods relative to other firms in the industry and 0 if its quality is at the industry average or below the average.
- *R&D.* This variable takes the value 1 for firms that undertake research and development and 0 otherwise.
- *Skill intensive.* This variable takes the value 1 if the skill levels of employees are (based on the perception of the manager) above the industry average and 0 if the skill levels are at or below the industry average.
- *Technical adaptation.* This variable takes the value 1 if a firm has technically adapted its machinery and equipment and 0 otherwise.

Experiments were carried out by forming four, five and six clusters. Forming six clusters brought a very uneven distribution of firms among clusters with some clusters ending up with very few or only one firm. Clustering into four groups, however, showed little clear distinction among groups. The data thus seem to suggest the formation of five clusters, where one group includes non-innovators and another group relatively highly innovative firms, with the other three clusters at varying levels of innovation.

5.5.2 Capability clusters and total factor productivity

Tables 5.5 and 5.6 present clusters of firms formed based on the eight technological capability indicators. The tables also report the average value of each indicator in the clusters. Because of the binary nature of the indicators, the average values are the shares of firms within each cluster that possess the respective technological capability. The tables also report the arithmetic mean of the eight capability indicators as an aggregate index of technological capability (the mean of means). This overall capability index is ranked in descending order and juxtaposed with the average TFP index of each cluster. Readers should be reminded that the TFP index is calculated based on manufacturing census panel data compiled by the Ethiopian CSA over the 1996–2002 period. The productivity index is the average level of the index for 2002 for those firms included in the sample survey conducted in 2004.

Referring to Table 5.5 it is evident that Cluster 1 comprises by far the most innovative group of firms. In this group 21.4% of firms had a technology license and 78.6% had technical assistance from abroad. This compares favourably with the industry average (the last row), where only 13% of manufacturing firms had technology license and only 18% had technical assistance. Close to 30% of firms in this innovative cluster provide employee training and conduct research and development – the highest share of all clusters. This cluster also ranks highest in terms of skill intensity and technical adaptation. In terms of quality of the product, however, this cluster ranks third. At the other extreme is Cluster 5, the non-innovative firms. None of the firms in Cluster 5 possess any of the technological capabilities used for the cluster analysis. The aggregate TC index therefore varies from zero for Cluster 5 to 0.58 for Cluster 1.

While clusters 1 and 5 are conspicuously different from each other and from the other clusters, differences in innovative capabilities are less stark among the other clusters, particularly, clusters 3 and 4. Clusters 3 and 4 have an overall TC index of about 0.25 each, while Cluster 2 is higher by about 10 percentage points. This suggests that while there is some complementarity between different innovative capabilities, the complementarity is not restrictive. In poor economies where capabilities are scarce, firms may attempt to achieve comparable levels of competence along different paths of capability building to the extent they are substitutes.

The cluster analysis does not show any distinct typology of capabilities. Rather, we find a group of highly innovative firms which engage in almost all technological activities and another cluster which undertakes none or only few of them. In-between are the other groups, which engage in different innovative activities with no clear tendency to focus on specific activities.

Table 5.5 : Technology clusters and technological capabilities of manufacturing firms (Kulczynsky similarity measure),faction of firms in a cluster with different technological capabilities

Technology Clusters	Technology License	Technical Assistance	Expatriate Staff	Employee Training	Quality Oriented	R&D	Skill Intensity	Technical Adaptation	Average Tech. Capability	Average Produc-tivity	Number of firms
1	0.214	0.786	0.643	0.286	0.786	0.286	0.786	0.857	0.580	5.134	14
2	0.174	0.000	0.261	0.000	0.870	0.087	0.478	1.000	0.359	4.142	23
3	1.000	0.000	0.333	0.000	0.333	0.000	0.333	0.000	0.250	1.700	3
4	0.031	0.125	0.031	0.125	1.000	0.125	0.500	0.000	0.242	2.912	32
5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.690	11
Total	0.133	0.181	0.205	0.096	0.771	0.120	0.470	0.422	0.300	3.398	83

Source: Author's computations based on sample survey.

Table 5.6 : Technology clusters and technological capabilities of Ethiopian manufacturing firms (Sneath similarity measure), faction of firms with different technological capabilities

Technology Clusters	Technology License	Technical Assistance	Expatriate Staff	Employee Training	Quality Oriented	R&D	Skill Intensity	Technical Adaptation	Average Tech. Capability	Average Produc-tivity	Number of firms
1	0.571	0.857	1.000	0.286	1.000	0.143	0.857	1.000	0.714	5.255	7
2	0.000	0.375	0.875	0.000	1.000	0.375	0.750	1.000	0.547	4.289	8
3	0.188	0.125	0.000	0.000	1.000	0.125	0.563	1.000	0.375	4.462	15
4	0.061	0.121	0.061	0.121	1.000	0.121	0.515	0.000	0.250	2.858	30
5	0.105	0.000	0.053	0.105	0.000	0.000	0.053	0.211	0.066	2.292	18
Total	0.133	0.181	0.205	0.096	0.771	0.120	0.470	0.422	0.300	3.398	78

Source: Author's computations based on sample survey.

Having done the clustering, it is interesting to observe that higher levels of technological capabilities correspond with higher levels of productivity (figures 5.9 and 5.10). Figure 5.9 shows that the innovative cluster, Cluster 1, is also the cluster with the highest level of productivity as calculated independently from the census-based panel data of manufacturing firms. Similarly, the least efficient group happens to be the non-innovative Cluster 5.

However, productivity does not decline monotonously with a decline in technological capabilities. For instance, Cluster 5 is a group of non-innovative firms but its productivity is not far below that of clusters 3 and 4. This observation has two implications. Firstly, firms can maintain an average level of productivity (productivity index of 1) by using their existing technologies efficiently. Secondly, there is no guarantee that technological capabilities are always translated into higher performance. This can happen either because the cost of building technological capabilities is higher than the benefits derived, or because technological capabilities are not fully exploited for reasons such as lack of incentives. This is consistent with the observation in section 5.4, which found that firms producing high-quality goods in the leather and footwear industry had poor performance in terms of productivity. Nevertheless, the correlation between accumulation of technological capabilities and relative productivity is evidently positive even in a sub-Saharan African economy like Ethiopia where innovative capabilities are scarce.

The preceding results are robust to the choice of clustering methods. The *Sneath* coefficient of similarity also leads to a clustering of firms in which innovative firms form a cluster that has the highest incidence of technological capabilities (table 5.6). The least innovative cluster in table 5.6 possesses none of the capabilities, as in table 5.5, or far fewer firms in the cluster happen to have the other technological capabilities. Figure 5.10 shows that the cluster ranking of firms by aggregate TC index is highly correlated to their TFP ranking.

Another way to look at the link between technological capabilities and firm productivity is to compare the cluster ranking of firms based on technological capabilities with their productivity ranking (instead of mean TFP) in 2002. The productivity ranking is based on quintiles for the entire population of manufacturing firms in 2002. Here, the first quintile comprises the most efficient 20% of firms while the fifth quintile contains the least efficient 20%. If technological capability determines the structure of the industry by deciding the relative productivity ranking of a firm, then we would expect close correspondence between the cluster ranks and the productivity ranks (table 5.7).

Table 5.7 shows that two-thirds of firms in the innovative cluster were also among the most productive 20% firms in 2002. It also shows that the proportion of firms in the most productive quintile (quintile 1) declines steadily as we go down the capability ranking. For instance, only 18% of firms in the non-innovative cluster belong to the most efficient quintile compared to the 67% and 52% share in the case of clusters 1 and 2. At the other end of the spectrum, nearly

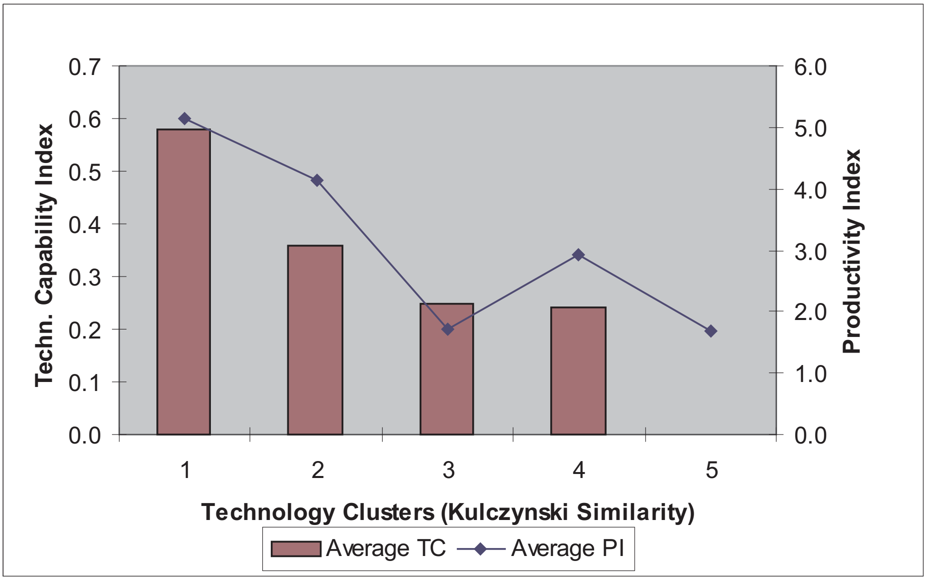


Figure 5.9: Technological capability clusters and average firm productivity (Kulczynski clusters)
Source: CSA manufacturing census and sample survey.

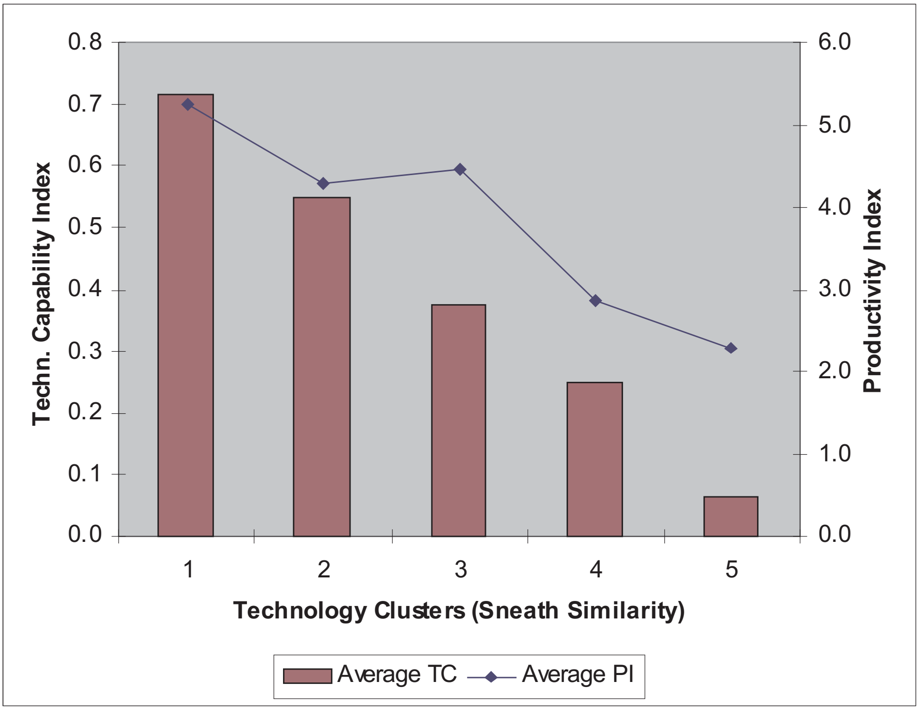


Figure 5.10: Technological capability clusters and average firm productivity (Sneath clusters)
Source: CSA manufacturing census and sample survey.

Table 5.7: Comparison of technological capability clusters and productivity quintiles (% of firms)

Technology Clusters	Productivity Quintiles				
	1	**2**	**3**	**4**	**5**
1	66.67	0.00	16.67	0.00	16.67
2	52.17	17.39	17.39	13.04	0.00
3	33.33	33.33	33.33	0.00	0.00
4	24.14	24.14	24.14	13.79	13.79
5	18.18	18.18	0.00	0.00	63.64

Source: CSA manufacturing census and sample survey.
Note: Quintile 1 is the most productive quintile and quintile 5 is the least productive. Numbers are row proportions adding up to 100 along a row.

two-thirds of the non-innovative firms belong to the bottom quintile in terms of productivity. The story is not so clear for firms with about average innovative capabilities and in the middle of the productivity ranking. But there is a tendency as already indicated for productivity to decline relatively slowly compared to the incidence of technological capabilities.

The capability clusters formed above also have an interesting size dimension. The most innovative clusters are dominated by medium-sized and large firms, while the least innovative firms are predominantly small in size.

Table 5.8 shows that more than 80% of the innovative cluster of firms are medium to large in size. Particularly with the Anderberg similarity coefficient there are no small firms in the most innovative cluster, while 55% to 60% of firms in the two least innovative clusters are small in size. The message is that accumulation of capabilities is more feasible – or that capabilities are better translated into performance – in relatively large firms compared to small ones.

Table 5.8: Firm size and technological capabilities (% of firms)

Clusters	Kulczynski Coefficient			Anderberg Coefficient		
	Firm Size			Firm Size		
	Small	**Medium**	**Large**	**Small**	**Medium**	**Large**
1	14.29	42.86	42.86	0.00	14.29	85.71
2	30.43	8.70	60.87	22.22	22.22	55.56
3	33.33	33.33	33.33	27.45	25.49	47.06
4	28.13	25.00	46.88	60.00	20.00	20.00
5	54.55	18.18	27.27	54.55	18.18	27.27
Total	30.12	22.89	46.99	30.12	22.89	46.99

Source: Sample survey.

5.6 Econometric estimates of the role of technological capabilities

The preceding sections reported bivariate associations of technological capabilities with firm-level efficiency. This section consolidates our understanding of such relationships using regression analysis. It tests the degree to which technological capabilities are associated with two indicators of performance: firm-level efficiency and expansion.

5.6.1 Technological capability and firm-level efficiency

An important hypothesis in the TC approach is that the accumulation of technological capabilities enhances the productivity of developing country firms. New machines embodying new technology may not be used at a best practice level of efficiency if firms lack the requisite technical capabilities. The level and technological composition of manufactured exports has been the most widely used performance parameter to measure the role of technological capabilities both at the firm level and at higher levels of aggregation. This section tries to explain variation in firm-level TFP using indicators of technological capabilities. Econometric models are specified in which indicators of technological capabilities feature on the right side together with other covariates. The capabilities that we anticipate capturing include a firm's experience and knowledge related to identifying and locating a foreign technology, its efficient use of such technology and ability to upgrade, and its ability to improve the quality of existing products and meet the requirements of the upper end of a product market. These capabilities are likely to be interdependent; and firms can draw them from different sources. The objective here is not to explain the process of technology capability accumulation but rather to find out whether the indicators (and the capabilities they represent) enhance the productivity of firms and the likelihood of business expansion.

The models to be estimated are the following:

$$\ln TFP_i = \gamma_0 + \sum_{i=1}^{n} \gamma_i TC_i + \delta_1 Size_i + \delta_2 Age_i + u_i \qquad (1)$$

$$\ln TFP_i = \alpha_0 + \alpha_1 TCINDEX_i + \alpha_2 Size_i + \alpha_2 Age_i + v_i \qquad (2)$$

The dependent variable in equations (1) and (2) is the natural logarithm of TFP calculated from the production function discussed in Chapter 3. TC_i in model (1) represents the following indicators of technological capability: licensing of foreign technology, foreign technical assistance, product quality, R&D, skilled labour and technical adaptation. As discussed in section 5.5.1 all of these indicators are dummy variables (1 if the firm undertakes that particular activity and 0 if not). Firm size is captured by the logarithm of employment and firm age is measured in years. Model (2) replaces individual technology capability indicators with a single aggregate index of technological capability. The aggregate TC index is constructed by adding all the indicators corresponding to a firm and dividing them by the number of indicators. Figure 5.11 shows the distribution of this index, once again reflecting the low incidence of technological capability accumulation in Ethiopian manufacturing. The aggregate index includes the technology capability indicators already included in model (1) plus two more indicators: presence of expatriate staff and employee training. These two are not included in model (1) to minimise collinearity with other indicators, most notably employee skill. The aggregate TC index, therefore, takes any value between 0 and 1 because of the nature of the individual indicators. Zero mean and constant variance error terms are represented by u_i and v_i. Table 5.9 reports the OLS estimates of the two models. Column 2 shows the results of model (1) and column 3 the results of model (2).

Starting with the results of model (2) in table 5.9, the coefficient of the aggregate TC index is positive and statistically significant at 5%. This underlines the importance of technological capabilities for firm-level efficiency as pointed out in the descriptive analysis. Although relatively few firms engage in accumulation of technological capabilities, such accumulation is clearly efficiency enhancing, by implication increasing firm survival. Using sales per worker as a measure of productivity, Teitel (2000) similarly found a statistically significant effect of an aggregate TC index for Zimbabwean firms. Looking at individual technology capability indictors, as reported in column 2, all of the indicators have the expected positive sign except for R&D, which has a negative but statistically insignificant coefficient. With the exception of technical assistance, the coefficients of all other technology capability indicators are statistically significant, most at the

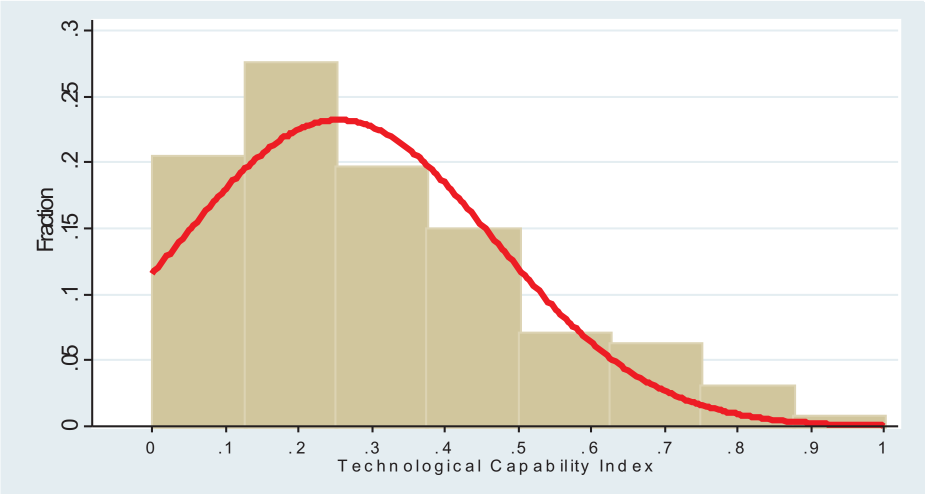


Figure 5.11: Distribution of aggregate TC index in Ethiopian manufacturing

Source: Author's computations based on sample survey.

Table 5.9: OLS estimates of technological capabilities, dependent variable – log TFP

	Model 1	Model 2
1	2	3
Technology License	0.6022**	
	(0.3091)	
Technical Assistance	0.3366	
	(0.3221)	
Product Quality	0.5241*	
	(0.2923)	
R & D	-0.5811	
	(0.3593)	
Skilled Labour	0.4595*	
	(0.2557)	
Technical Adaptation	0.4164*	
	(0.2231)	
Technological Capability Index		0.3186**
		(0.1327)
Firm Size	0.1908**	0.1596***
	(0.0900)	(0.0526)
Firm Age	0.0232***	0.0129*
	(0.0081)	(0.0076)
Intercept	-1.7171***	
	(0.3832)	
Number of Observations	77	91
Adjusted R2	36.31	35.02

Note: Heteroscedasticity corrected standard errors are in parenthesis.

10% level. This is to be expected, since capabilities are correlated with each other and also with firm size, which tends to reduce the signal-to-noise ratio.

Technology licensing from abroad plays the leading role, being significant at 5.5%. Although this indicator measures whether the firm has a technology license, this author prefers to interpret it as an indictor of a firm's ability to identify a relevant technology, locate its source and enter into a technological contract with a technology supplier. In that sense it represents more than a technology input in terms of a patent or blueprint. Such capability is likely to stay with the firm long after a particular license expires. The results also indicate that skilled labour is an important determinant of firm-level differences in efficiency as discussed earlier. There is a lot of micro-level literature on the key role of education for individual income, while the growth literature also shows evidence of a positive role of human capital at the macro level. By uncovering the role of skills in firm-level productivity, the findings in this chapter reveal some of the channels through which education leads to economic growth and increased personal welfare. Similarly, firm efforts in technical adaptation boost efficiency, although most instances of technical adaptation, as discussed in the previous section, aim at reducing maintenance requirements. Perceived product quality is included in the regression to capture other capabilities, such as design, packaging and marketing, which add value to the product and enable a firm to penetrate the top end of a particular product market. Its coefficient is statistically significant and has important implications for firm survival and growth, since the top end of a product market in most industries involves direct competition with imported goods.

Productivity also increases with firm size and age in conformity with the predictions of market selection models.[7] The size effect is larger than the age effect in both models. The argument is that large firm size not only allows spreading of costs associated with innovation over a large volume of output, but it also permits specialisation which goes with technological advancement.

5.6.2 Technological capabilities and firm growth

Do firms accumulate technological capabilities as part of their growth strategy? In other words, how important are technological capabilities in determining firm growth prospects? The technological capabilities approach to industrial competitiveness underscores the tendency among developing country firms to refrain from venturing into technologically advanced products and industries because of the associated costly and risky learning process. Much of the theoretical discussion regarding the TC approach relates to explaining differences in overall economic growth and competitiveness in a developed-developing country framework, without dwelling much on inter-firm differences in technological capabilities within a developing country and its implications for firm-level growth.

This final section investigates the association between technological capabilities and firm growth in a poor developing country context. One obvious way to do so is to use regression analysis to explain variation in observed firm growth rates based on differences in technological capabilities. Following a slightly different path, we explore business plans for expansion (growth) over a five-year horizon conditional on contemporaneous technology capability indicators.[8] The dependent variable to be explored is therefore the likelihood of firm growth over a five-year period and not the actual growth rate. Like the TFP regression, the growth regression will also be estimated for two models: one with individual technology capability indicators and another with an aggregate TC index.

$$G_i = \gamma_0 + \sum_{i=1}^{n} \gamma_i TC_i + \sum_{j=1}^{k} \delta_j Z_j + e_i \tag{3}$$

$$G_i = \alpha_0 + \alpha_1 TCINDEX_i + \sum_{j=1}^{k} \delta_j Z_j + \varepsilon_i \tag{4}$$

where G_i is a dummy variable taking the value 1 if the firm plans to expand in the coming five years and 0 otherwise. Z_i is a vector of control variables for firm size, age and industry, while e_i and ε_i are white noise.

Before estimating the regression models let's look at some descriptive statistics. The literature on firm growth often uses firm age and size as key explanatory variables. About 68% of the sample firms have plans to expand their business in the coming five years. It is interesting to note that very old firms established in the imperial regime (before 1974) were less likely to have expansion plans than firms established since the 1991 economic reform programme. About 87% of the latter plan to expand in the coming five years, compared to only 41% of the former. Firms established under the military rule (1974–1990) have a 62% likelihood of planning expansion. The likelihood of business expansion therefore tends to decline with firm age. Similarly, only 48% of large firms intend to grow in the coming five years, compared to about 80% among small and medium-sized firms. The negative age and size effects are consistent with findings in the literature and also with the regression results reported in Chapter 4 for the entire population of manufacturing firms.

Returning to technological capabilities, variation in growth prospects is observed across firms based on their (perceived) level of human capital. Among firms which believe they have *very highly* skilled labour, about 93% have plans to expand in the coming five years, which is 20 percentage points higher than the proportion among firms that believe they have *highly* skilled employees. The probability of growth falls to 60% among firms that believe they have average skill levels (about 30 percentage point below the first group). Similarly, there is a strong association between the quality of a firm's output and its expansion plans. About 73% of the firms that believe they produce the highest quality or the second best quality in the industry have plans for expansion, which is much higher than the 57% likelihood among firms at the industry average.

The data also show that 83% of firms with a technology license have plans for business expansion compared to 66% among those firms without such a license. Similarly, all firms (100%) that have technical assistance plan to expand their business over the coming five years (62% of firms do not have technical assistance from abroad). Employing expatriate staff also increases the likelihood of firm growth plans, compared to firms that employ no expatriates. The impression left by these findings is that business growth is closely connected to internal capabilities in terms of skilled labour, product quality and access to foreign technology. If this effect is statistically significant, it would imply that growth is not just a matter of investment; it has important links with technological capabilities, which become even more relevant as economies open up to international competition.

Table 5.10 presents the results of the probit regression of planned growth for equations (3) and (4) using the explanatory variables discussed above. For skill levels of employees a dummy variable is defined which takes the value 1 if a firm perceives itself as having employees with skills above the industry average and 0 if employee skills are at or below the industry average. Dummy variables also identify firms with product quality above the industry average, firms with a technology license and those with technical assistance from abroad. There are also age dummies that identify firms entering an industry before the 1974 revolution,

Table 5.10: Technological capabilities and the probability of firm growth, probit estimates and marginal effects

	Coefficients	Marginal Effects	Coefficients	Marginal Effects
1	2	3	4	5
Technology License	0.5267	0.1491		
	(0.5259)	(0.1234)		
R&D	0.0726	0.0235		
	(0.4842)	(0.1540)		
Skilled Labour	0.6956**	0.2157**		
	(0.3277)	(0.0956)		
Expatriate Staff	0.1404	0.0449		
	(0.3970)	(0.1232)		
Product Quality	0.6057*	0.2109		
	(0.3729)	(0.1333)		
Technological Capability			0.8560***	0.2227**
Index			(0.3174)	(0.0917)
Medium Size	-0.1826	-0.0619	-0.2444	-0.0671
	(0.4389)	(0.1530)	(0.6173)	(0.1811)
Large	-1.2451**	-0.4226***	-1.4532***	-0.3961***
	(0.4089)	(0.1344)	(0.4389)	(0.1321)
Entry Before 1974	-1.1165**	-0.3992***	-1.0698**	-0.3272**
	(0.3709)	(0.1316)	(0.4602)	(0.1482)
Entry During 1974 to 1991	-0.7158*	-0.2534*	-1.0955**	-0.3358**
	(0.3822)	(0.1388)	(0.4388)	(0.1371)
Leather and Footwear	0.8852**	0.2440***	1.2089**	0.2276***
	(0.4186)	(0.0916)	(0.4955)	(0.0685)
Chemical and Plastic	0.7076*	0.2069**	0.9946**	0.2142***
	(0.4198)	(0.1056)	(0.4701)	(0.0818)
Metal and Light Machinery	0.2338	0.0742	0.6248	0.1396
	(0.4004)	(0.1221)	(0.4639)	(0.0874)
Intercept	0.4042	0.1491	2.6287***	0.2227
	(0.3793)	(0.1237)	(0.7376)	(0.0917)
Observations	114		95	
Pseudo R^2	32.12		37.23	

Note: Heteroscedasticity corrected standard errors are in parenthesis.

between 1974 and 1991 and after the 1991 economic reform programme. Firms established since the economic reform in 1991 serve as the reference category. Both models include dummy variables for firm size as well as industry. Columns 2 and 3 are results based on equation (3) while columns 4 and 5 report the results of equation (4).

The estimated probability models in table 5.10 show firm size and age to be negatively correlated with the probability of growth. The negative size effect is particularly noticeable and statistically significant among large firms. Compared to firms born after the 1991 economic reform programme, firms established during the imperial regime and those established during the military regime have lower probabilities of growth. The age effect is negative and significant at 1% for firms established before 1974. It is interesting to note that the size and age effects are consistent with the theoretical expectations and other empirical studies which measure growth as a continuous variable.

After controlling for the standard age and size effects and also industry-specific effects, skill differences have important implications for the likelihood of firm growth. Firms that employ highly skilled workers are more likely to grow than firms with industry-average skill levels. Similarly, firms that have the technological capabilities to produce high-quality goods have better prospects for growth than firms producing at just the industry average or below the industry average. This last is significant at the 10% level. These results underline the role of skills, experiences and knowledge in capturing growth opportunities in an industry. Although technology licensing is positively related to growth, its effect is not statistically significant. The same applies to employing expatriate staff, which has an imprecise positive effect. Firms' access to technical assistance was dropped from the model because it predicts 100% success rate in terms of growth probability – all firms with technical assistance had plans to expand their business in the coming five years. Therefore, the coefficient cannot be estimated, although it is clear that it promotes firm growth.

Although multicollinearity may reduce the precision with which the growth effect of technological capability indicators are measured, the results in columns 4 and 5 reveal that the aggregate TC index has a statistically significant positive association with the likelihood of firm growth. The regression results, therefore, suggest that although the overall incidence is quite limited, accumulation of technological capabilities is part of a business strategy for expansion. The policy implication is that correcting the macroeconomic incentive framework to boost investment is not going to be sufficient for industrial progress in developing countries. Facilitating and supporting firms' efforts to build technological capabilities should equally be emphasised if enterprises are to continue to expand and create jobs.

5.7 Conclusions

This chapter looked at key aspects of firm-level accumulation of technological capabilities and the relation of such capabilities to firm-level performance. The analyses showed that few firms in Ethiopian manufacturing engage in systematic accumulation of technological capabilities. In general, medium-sized and large firms were more active than small firms in acquiring technological capabilities. This reflects the conditionality of the returns to capability building on firm size. The Ethiopian data also show the important implications of post-entry investment on skill demands, depending on the main purpose of such investment. Expansion along the same product line seems to demand few new skills, which is why such investment is more prevalent among small firms. Consistent with the precepts of the TC approach, the demand for skills and the likelihood of experiencing skill shortages tend to increase as firms attempt to introduce new products and new varieties of existing products. Given the historical significance of new products and processes for industrial progress, the implication of this observation is that the expansion and competitiveness of African manufacturing industries requires improving not only the macroeconomic incentive framework but also the availability of advanced technical skills in the labour market. Given the low level of human capital and the market failures in on-the-job training, building technological capabilities to enable African manufacturing firms to catch up and keep up even with leaders in the developing world constitutes a huge challenge.

It is interesting to note that despite its limited incidence, the accumulation of technological capabilities tends to enhance firm-level efficiency. The regression results show a positive association between firm-level productivity and individual indicators of technological capabilities as well as the aggregate TC index. Although we have no time series data on technological capabilities, the increase in the dominance of small firms in Ethiopian manufacturing over the study period plus the positive association between innovation and firm size suggest that accumulation of technological capabilities has been on the decline. That means the high rate of entry by small firms exerts a dampening effect on the sector-level incidence of technological capability accumulation, even if innovative incumbents do not reduce their innovative efforts. The intra-firm productivity decline documented in Chapter 3 therefore partly reflects a declining incidence of technological capability accumulation as a result of the size distribution of firms shifting to the left.

The empirical analyses also indicated that firms accumulate technological capabilities in anticipation of growth; another performance indicator examined in this chapter. Firms that build technological capabilities are more likely to grow, controlling for size and age effects. Therefore interventions that widen the avenues for technological learning and/or reduce the cost of doing so could enhance industrial competitiveness. This important observation runs against the traditional perception that innovation is not so crucial for developing countries' manufacturing (particularly for the least developed countries) given their low level of development. To the extent that firm expansion depends on within-firm capabilities, the success of correcting the incentive framework and restoring macroeconomic stability in terms of soliciting private-sector response will depend on the robustness of the process of technological capability building.

Our attempt to find typologies of technological capabilities using cluster analysis was unsuccessful. The analysis, rather, found two clearly distinct clusters of firms – one group that engaged in accumulation of almost all the indicators of technological capability used in this study and another group which did not do any (or only a few) of the innovative activities. The other three clusters engaged in such accumulation in a manner that does not permit easy distinction. However, the ranking of the clusters of technological capability is positively associated with firms' productivity ranking, suggesting that average productivity increases with the intensity of technological activities across all clusters.

The cluster analysis also revealed that the link between productivity and technological capability clusters is not always neat and clear. For instance, average

TFP does not decline monotonically with the decline in the ranking of technological capability clusters from most innovative to least innovative. This points to the fact that building technological capabilities does not always translate into higher performance in terms of TFP. One reason is asymmetry in the cost and benefit of accumulating technological capabilities. While building technological capabilities definitely has cost implications, there is uncertainty as to its outcomes. Hence, not all innovative firms are highly productive. The other possibility is that capabilities may not be fully utilised if incentives are distorted; bringing back the importance of appropriate incentives and functioning markets.

A more complete analysis would require panel data to learn whether changes in the accumulation of technological capabilities result in productivity improvements and firm expansion. The results in this chapter, however, showed a strong positive association which might be biased upwards, as efficiency increases profitability which in turn increases firms' ability to accumulate technological capabilities. Nonetheless, in a competitive environment one would not expect firms to continue to build technological capabilities simply because they have the resources to do so, unless such capabilities have payoffs in terms of improving a firm's relative efficiency in an industry. The finding that investment in new products is likely to be constrained by skill shortages is supportive of the latter view. In conclusion, long-term industrial competitiveness requires a focus on the accumulation of technological capabilities, which were shown to have important implications for efficiency and growth even in countries like Ethiopia where the manufacturing sector is not export oriented.

Notes to Chapter 5

1 Mytelka (1979), Dahlman (1984), Kaplinsky (1984), Ozawa (1980) and UNCTAD (1978).

2 A parallel can also be drawn with the global value chains analysis in which the ability of developing country firms to benefit from such linkages depends among other things on their capabilities to deliver high-quality products at the right time (Humphrey and Schmitz 2002, Schmitz and Knorringa 2000)

3 The CIP was constructed by giving equal weight to each of the four indicators, which were also converted into indices themselves.

4 Overall, 91% of entrants acquired their machines either fully or mainly from abroad.

5 Although tariffs were simultaneously lowered with devaluation, the effect on import of machines was insignificant, as machines were subject to either zero or the minimum tariff before the 1991 reform.

6 An exploratory regression analysis (not reported here) confirms that starting with new machines and importing machines from abroad increases productivity significantly, as stated above. However, firms that started with used machines were not significantly less efficient than those that started with new machines. In fact, it was firms starting with a mixture of new and used machines that were significantly less efficient than firms starting with only new machines. Further exploration shows that this is due to the tendency among firms that mix old and new machines to also mix imported with locally acquired machines. On the other hand, firms that begin with used machines predominantly import them from abroad.

7 Industry dummies were not included as the dependent variable was transformed into an index by normalising through the mean industry practice for each industry. An experiment including such dummies in the regression model shows that they are statistically insignificant.

8 Firms were asked whether they plan to expand their business in the coming five years. The survey question does not specify whether the expansion is in terms of employment or sales. It is likely that the response refers to a bit of both.

6 Investment Behaviour of Manufacturing Firms

6.1 Introduction

The third dimension of competitiveness dealt with in this study is firm-level investment. In the previous chapters, the proper functioning of markets and firm-level accumulation of technological capabilities were shown to contribute to industrial competitiveness. However, competitiveness requires relative efficiency and innovativeness be put to productive use through investment. It is important, therefore, to investigate the capital adjustment patterns of African firms and potential problems in adjusting capital to a desired level, including adjustment costs, uncertainty and irreversibility.

The early literature on development economics considers capital formation to be the main driver of economic growth. The "Big Push" hypothesis, for instance, underscores the importance of increasing returns to a coordinated large investment in a number of sectors, while others focus on investment in a "lead sector" that would pull the rest of the economy through forward and backward linkages. For developing countries, investment has also been regarded as the most viable if not the only channel for access to modern technology from abroad. This near exclusive focus on investment has gradually given way to more balanced views that take into account other aspects of economic growth. For instance, by emphasising the crucial distinction between production systems on the one hand and knowledge and technology systems on the other, the technological capabilities literature asserts that the answer to industrial competitiveness does not lie entirely within the production system(Bell and Albu 1999). Similarly, new growth and trade theories focus on innovation and its dynamics for long-term growth in per capita income (Aghion and Howitt 1998). Although accumulation of capital does not address all of the challenges of industrial progress, investment remains of critical importance in the development process. As a forward-looking activity, investment is more than capital accumulation. It involves the formation of expectations about future streams of returns and risk-taking by entrepreneurs in an uncertain environment. Investment has been one of the most volatile components of the macro economy making it an interesting area of research. At the policy level, investment has assumed centre stage as structural adjustment programmes have sought to create and maintain a favourable investment climate that allows the private sector to flourish.

While theoretical models of investment have managed to go beyond user costs and aggregate demand to incorporate delicate issues of expectation and uncertainty, their empirical performance in explaining investment remains far from satisfactory (Chirinko 1993). Until recently the empirical literature on investment relied heavily on cross-country studies of gross capital formation and time series analyses for individual countries. Firm-level analysis of investment behaviour gained new impetus in the past two decades owing to the increasing supply of micro-data. This chapter contributes to the emerging literature on investment behaviour of African manufacturing firms by probing the capital adjustment patterns of Ethiopian manufacturing firms. The main thrust of the chapter is to understand the patterns and determinants of firm-level investment and its role in industrial competitiveness in the context of sub-Saharan Africa. Previous chapters showed that African markets do select efficient firms and that innovation tends to be efficiency enhancing. It remains to be seen whether capital accumulation is consistent with market selection and most importantly whether innovative firms take advantage of their competitive edge through expansion of their capital stock.

The chapter is organised as follows. The next section describes capital adjustment patterns in Ethiopian manufacturing and compares them with adjustment patterns in Europe and in other sub-Saharan African countries. Section 6.3 analyses the persistence of investment rates using a one-period transition probability and employs this information to distinguish between alternative explanations of observed adjustment patterns. Section 6.4 deals with the determinants of investment; it analyses both the decision to invest and the variation in the rate of investment with emphasis on the role of irreversibility and uncertainty. Section 6.5 relates investment to productivity and accumulation of technological capabilities. In doing so it uses some of the results in the previous chapters, examining their interdependence with investment. Section 6.6 draws some conclusions.

6.2 Capital adjustment patterns

The analyses in the following sections mainly use the census-based panel data of Ethiopian manufacturing firms compiled by the CSA. Investment rate is defined as total firm-level investment as a fraction of the previous year's capital stock. Capital stock is calculated as the capital stock of the initial year plus investment minus depreciation minus capital sales. There is no information on funds put aside by firms for the sake of capital replacement. Depreciation is therefore calculated using a 10% depreciation rate for machinery and vehicles and 5% for buildings. Profit rate refers to a firm's gross operating surplus calculated by subtracting wages from value-added.

The macroeconomic environment in Ethiopia has been fairly stable since the start of the economic reform programme in 1991 (figure 6.1). Inflation has essen-

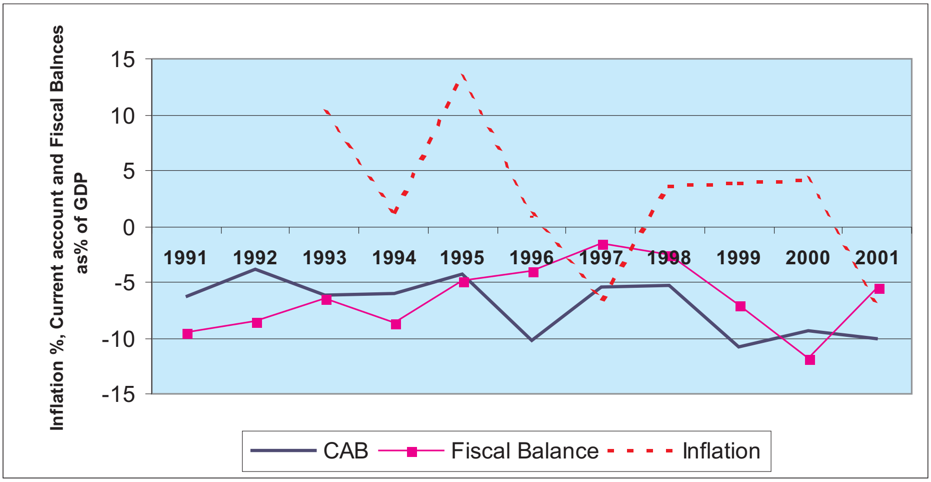


Figure 6.1: Selected macroeconomic indicators for Ethiopia
Source: National Bank of Ethiopia and IMF country reports.

tially been kept in the lower single digits including a few instances of deflation. The fiscal deficit has been steadily reduced from about 10% of GDP to less than 5% except for some relapse during the Ethio-Eritrean border conflict. Although the current account balance has been persistently in deficit, this reflects only the country's dependence on aid and does not pose a major threat to macroeconomic stability. As highlighted in the introduction, the country has an attractive investment code which through a series of revisions has expanded the scope of economic activity and incentives offered to the private sector. Judging by macroeconomic indicators and the investment code, Ethiopia seems to offer a favourable investment climate by developing country standards.

However, recent trends in private sector borrowing and investment belie the uncertainty beneath the apparently stable macroeconomic environment. Figure 6.2 shows that despite the stable macroeconomic environment, private sector borrowing from the domestic banking system has been declining especially since 1996. It is interesting to note that this steady decline began after the introduction of the Bank Foreclosure Law in 1997/98, which authorises banks to auction the mortgaged assets of defaulting borrowers. The declining trend seems to have been exacerbated by the 2001 Anti-Corruption Law (which implicated several business leaders and bank officials) leading to a negative credit flow to the private sector in 2002. Unsurprisingly, during this period commercial banks in Ethiopia have been awash with excess liquidity making it clear that a stable macroeconomic environment does not necessarily induce firms to borrow and banks to lend.

In line with the recent time path of credit to the private sector, the rate of investment in Ethiopian manufacturing, aggregated from firm-level investment, declined during the period 1997 to 2002 from about 16% to about 8% (figure 6.3).

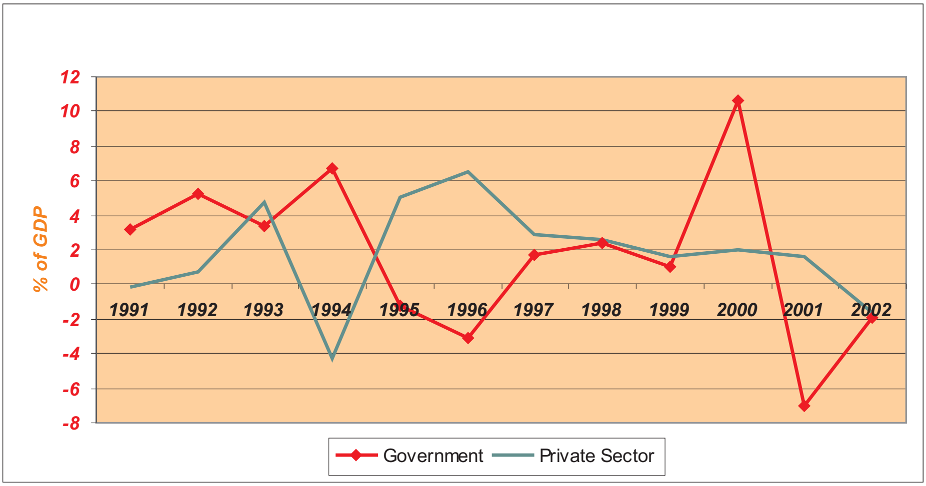


Figure 6.2: Credit to government and the private sector
Source: National Bank of Ethiopia and IMF country reports.

In the meantime, average profit rates in Ethiopian manufacturing remained high and comparable to other African countries.

The apparent paradox between high profitability and low investment in African manufacturing was also noted by Bigsten et al. (1999). Their findings are reproduced here for the sake of comparison. Figure 6.4 compares profit rates for five sub-Saharan African countries with profit rates for a sample of European

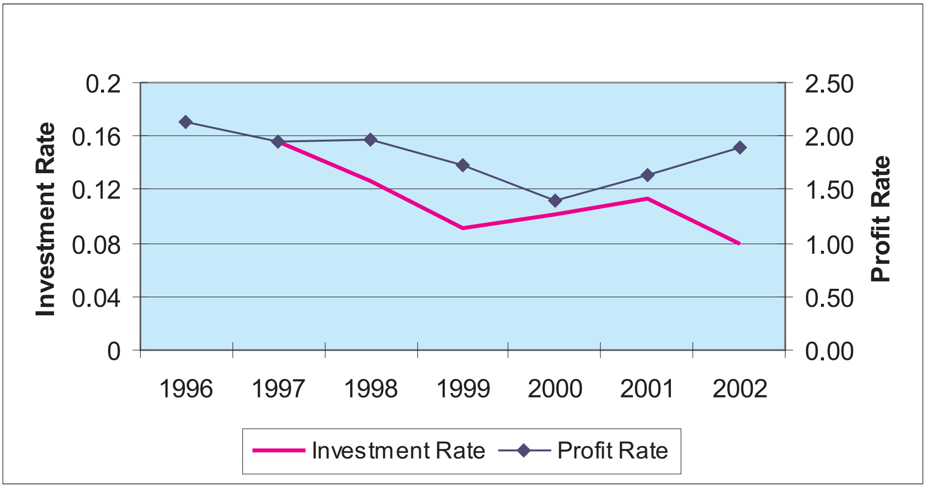


Figure 6.3: Trends in profit and investment rates in Ethiopian manufacturing
Source: Author's computations based on CSA manufacturing census.

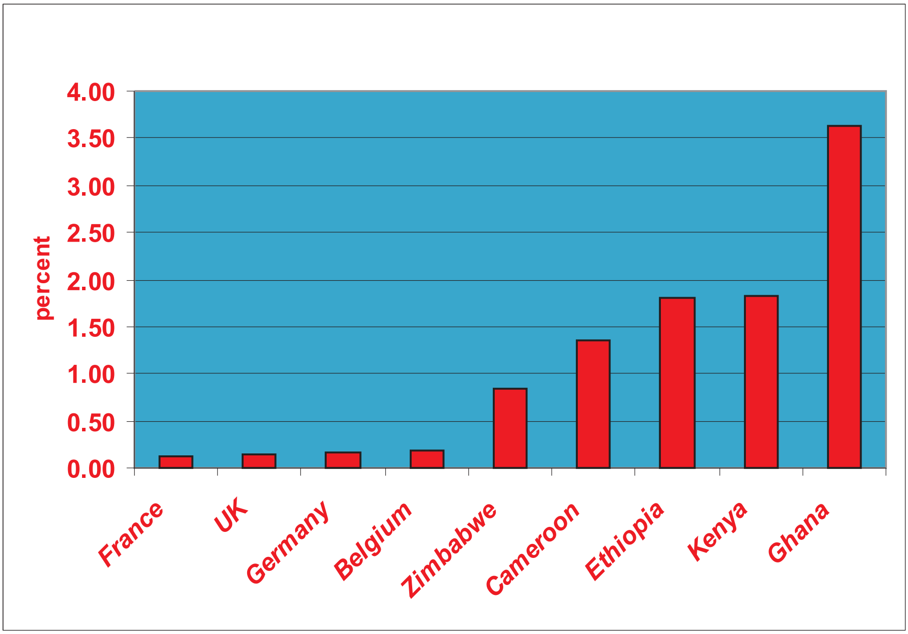


Figure 6.4: Average profit rates in Africa and Europe

Source: CSA for Ethiopia, Bond et al. (1997) for Europe and Bigsten et al. (1999) for other sub-Saharan African countries.

countries studied by Bond et al. (1997). It shows the average profit rate in African countries to be at least 10 times higher than that in European countries, which is about 11%.

On the other hand, figure 6.5 shows that the mean investment rate in African manufacturing is comparable if not less than that in EU manufacturing. The first impression from this comparison is that African firms do not plough their profits back into their firms in the form of investment, at least not in the same establishment. This behaviour is consistent with that expected in an uncertain business environment in which only very high rates of return would trigger firms to invest.

Given that the majority of African firms have zero investment at any point in time (figure 6.6), the median investment rate in the region is close to zero (Bigsten et al. 1999). This also implies that the mean investment rate among investing firms in Africa must have been very high for the overall average investment rate to level with that of European countries. The major pattern of capital adjustment in African countries therefore combines lumpiness with high incidence of zero investment rates – a pattern to be explored further in the following sections using firm-level data from Ethiopian manufacturing.

Table 6.1 reveals several features of investment in Ethiopian manufacturing. The first is that on average more than half of establishments have zero investment rate (IR=0) during a period of one year and this share was higher in 2002 than in

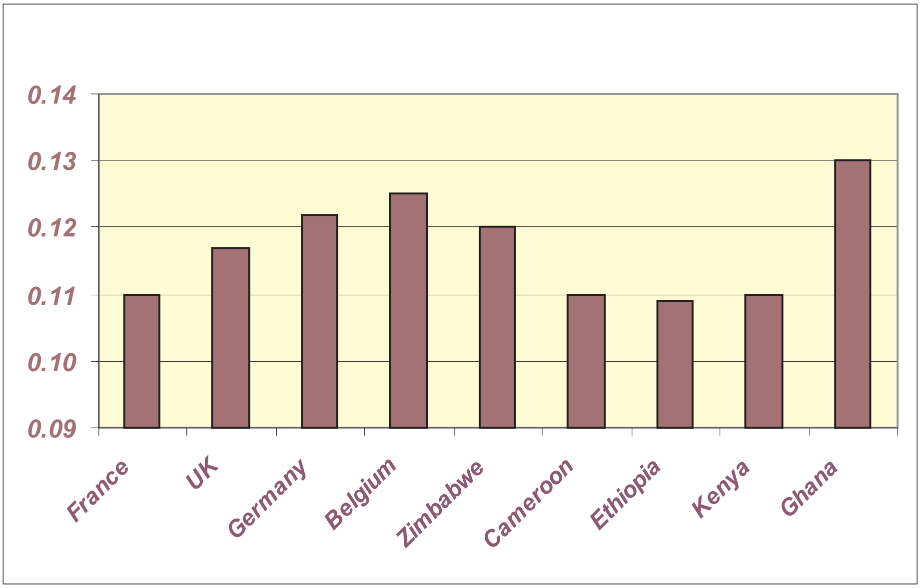


Figure 6.5: Average investment rates in Africa and Europe

Source: CSA for Ethiopia, Bond et al. (1997) for Europe and Bigsten et al. (1999) for other sub-Saharan African countries.

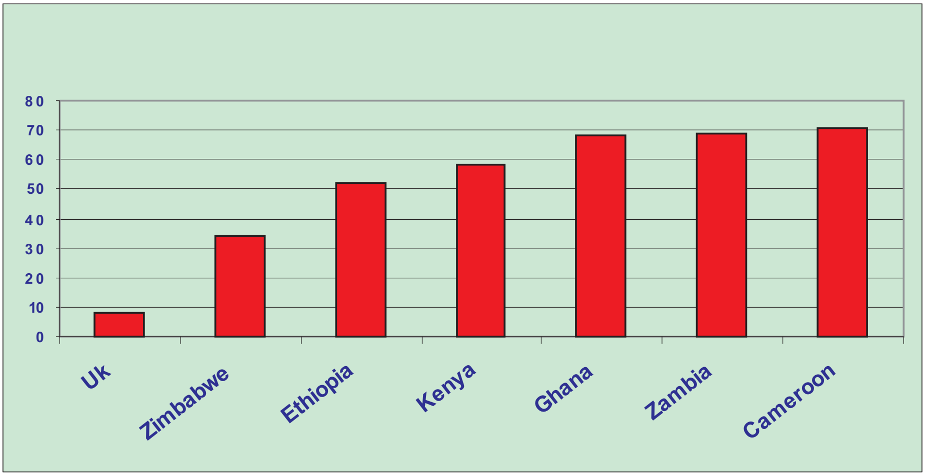


Figure 6.6: Proportion of manufacturing firms with zero investment rates

Source: CSA for Ethiopia, Bond et al. (1997) for Europe and Bigsten et al. (1999) for other sub-Saharan African countries.

Table 6.1: Distribution of gross investment rate by industry

	IR=0		0 <IR=5%		5<IR=10%		10<IR=20%		IR>20%	
	1997	**2002**	**1997**	**2002**	**1997**	**2002**	**1997**	**2002**	**1997**	**2002**
Food & Beverage	57.0	60.1	15.6	17.9	5.5	6.9	7.0	5.2	14.8	9.8
Textile & Garments	53.9	63.3	23.1	23.3	0.0	3.3	3.9	6.7	19.2	3.3
Leather & Footwear	46.8	41.9	17.0	9.3	10.6	7.0	12.8	27.9	12.8	14.0
Wood & Furniture	58.8	56.0	11.3	23.0	6.3	5.0	8.8	6.0	15.0	10.0
Printing & Paper	43.6	51.7	18.0	20.7	2.6	10.3	5.1	1.7	30.8	15.5
Chemical & Plastic	32.6	42.2	13.0	26.6	4.4	9.4	15.2	6.3	34.8	15.6
Non-Metal	61.4	56.7	8.8	23.3	8.8	10.0	7.0	5.0	14.0	5.0
Metal	46.4	43.2	21.4	29.6	3.6	13.6	10.7	6.8	17.9	6.8
Machinery	58.8	53.9	17.7	23.1	0.0	7.7	5.9	7.7	17.7	7.7
Total	52.6	54.2	15.4	21.3	5.3	7.6	8.3	7.0	18.4	9.9

Source: Author's computations based on CSA manufacturing census.
Note: The numbers add to 100 across columns for 1996 and 2002. Investment rate is the ratio of current investment to lagged capital stock.

1997. Some industries, such as food and beverages, textile and garments, wood and furniture, non-metal and light-machinery, exhibited zero investment episodes of higher than 50%, both in 1997 and 2002. Second, about one-quarter of firms (21% to 25%) had positive but not more than 10% investment rates. Most of these actually had an investment rate of less than 5%, an amount that was likely associated with minor replacements and maintenance. It appears that about three-quarters of manufacturing establishments in Ethiopia had investment rates well below the 10% depreciation rate commonly applied in empirical studies. Finally, only 7% to 8% of firms fell into the 10% to 20% investment rate category, which would lead to an increase in capital stock. Averaging across industries, about 18% of firms had investment rates in excess of 20% in 1997, although the share of such firms had declined by half, to about 10%, by 2002. The remainder of this chapter refers to investment rates in excess of 20% as "lumpy investment" or "investment spikes". In general, investment does not occur frequently in Ethiopian manufacturing, and when it does it happens in large spurts that would increase capital stock substantially. This lumpiness of investment is similar to many other developing and developed countries.

Table 6.2 shows that the proportion of firms with zero investment declines with firm size. Nearly two-thirds of small firms have zero investment, while this proportion is less than one-quarter among large firms. Small and medium-sized firms appear to account for most of the increase in the incidence of zero investment in 2002 across industries. On the other hand, lumpy investment is more likely to occur among large firms as compared to small and medium-sized estab-

Table 6.2: Distribution of gross investment rate by firm size

	IR=0		0 <IR=5%		5<IR=10%		10<IR=20%		IR>20%	
	1997	**2002**	**1997**	**2002**	**1997**	**2002**	**1997**	**2002**	**1997**	**2002**
Small	68.7	69.7	9.5	14.2	4.0	5.2	5.1	4.6	12.7	6.4
Medium	46.2	50.4	23.1	23.7	2.2	7.2	8.8	6.5	19.8	12.2
Large	22.7	22.6	22.7	34.9	10.2	13.7	14.8	13.0	29.7	15.8
Total	52.6	54.2	15.4	21.3	5.3	7.6	8.3	7.0	18.4	9.9

Source: Author's computations based on CSA manufacturing census.

lishments. This divergence in the lumpiness of investment by firm size was less stark in 2002, because the incidence of lumpy investment had declined drastically in all size categories. The main observation here is that most of the zero investment episodes occurred at the lower end of the firm size distribution, while lumpy investment frequently occurred at the upper end of the distribution. It is also important to note that peripheral investment (below the depreciation rate) is relatively more frequent among large firms than in small and medium-sized firms. This situation, coupled with the inverse relation of zero investment to firm size, implies that capital adjustment is relatively smoother among large firms.

Disaggregated investment

On average, about 56% of total capital stock in Ethiopian manufacturing consists of machinery and equipment, while buildings and vehicles account for about 38% and 6%, respectively. Table 6.3 explores the rigidity in the adjustment of these three categories of capital. In terms of investment, on average 46% of total investment during 1996–2002 was in machinery, about 40% in buildings and 15% in vehicles. As shown in the table, aggregation tends to reduce the rigidity in capital adjustment, as the relative frequency of zero investment is much higher for disaggregated items than for aggregate firm-level investment. For instance, the incidence of zero investment for aggregate investment is 53%, while it is 66% for machinery and 84% for buildings and vehicles. This is to be expected, since aggregate investment will be positive if a firm invests in at least one of the three capital items. In all investment categories, the zero investment episode declines with firm size while the incidence of investment spikes (IR>20%) increases with size. Irrespective of firm size, capital adjustment in machinery tends to be relatively smoother than investment in buildings and vehicles, where zero investment episodes are rampant. The incidence of zero investment in buildings and vehicles is about 20 percentage points higher than in machinery. While the general pattern is the same in the three investment categories, the difference among them probably has more to do with their relative importance in the production process rather than their reflecting differences in capital adjustment costs in the three categories.

Table 6.3: Distribution of disaggregated investment by firm size

	IR=0	0<IR=5%	5<IR=10%	10<IR=20%	IR>20%	Total
Machinery						
Small	79.7	7.0	3.5	2.9	6.9	100
Medium	62.8	13.0	5.1	4.6	14.6	100
Large	35.8	30.8	7.7	10.3	15.4	100
Total	65.8	13.9	4.8	5.0	10.6	100
Building						
Small	92.2	2.3	1.0	1.2	3.3	100
Medium	82.8	7.9	1.6	2.1	5.5	100
Large	64.9	17.1	4.1	3.2	10.8	100
Total	83.7	7.0	1.9	1.9	5.5	100
Vehicle						
Small	96.3	0.8	0.3	0.2	2.5	100
Medium	84.1	1.4	1.6	1.9	11.0	100
Large	56.1	6.8	4.1	4.3	28.8	100
Total	84.2	2.3	1.5	1.5	10.5	100
Aggr. Investment						
Small	70.0	12.7	4.2	4.3	8.9	100.0
Medium	46.0	23.5	7.1	7.8	15.7	100.0
Large	20.0	32.8	12.6	11.9	22.7	100.0
Total	53.0	19.8	6.8	6.8	13.6	100.0

Source: Author's computations based on CSA manufacturing census.
Note: Numbers are for the entire 1996–2002 period across all industries.

How do these observations compare with investment patterns in other countries? For UK manufacturing, Attanasio, Pacelli and Reis (2000) found zero investment episodes of 58%, 25% and 2.3% for buildings, vehicles and machinery, respectively. While the prevalence of zero investment, particularly in buildings and vehicles, is broadly similar in both countries, the frequency of zero investment in Ethiopian manufacturing lays bare the difficulties of capital accumulation encountered by African firms. Very high fixed adjustment costs and uncertainty are some of the major culprits emphasised in the literature. Looking at aggregate investment, the share of firms with lumpy investment in Ethiopia is 13.6%, which is more than twice the corresponding figure for the United Kingdom (5.4%).

For a group of five sub-Saharan African countries, Bigsten et al. (2005) found that the vast majority of firms had zero investment rates, an even higher rate than in Ethiopia (see figure 6.6). Data from the Regional Program on Enterprise Development (RPED) for the early 1990s indicate zero investment rates for 71% of firms in Cameroon, 69% in Zambia, 68% in Ghana, 58% in Kenya and 34% in Zimbabwe.[1] They also report that among those firms with positive investment, 27% had investment rates in excess of 20% for data pooled across the five countries. This is equivalent to about 11.3% (27% of 42%) of the total number of firms in the full sample – including those firms with zero investment – which is comparable to the share of firms with investment spikes in Ethiopian manufacturing (i.e., 13.6%). These findings suggest that manufacturing firms in sub-Saharan Africa face higher fixed adjustment costs and/or greater uncertainty than firms in developed countries.

Contribution of investment spikes

Compared to developed countries, lumpy investment is more frequent and accounts for a greater part of total investment in sub-Saharan Africa .

Table 6.4 indicates that, although just a few firms have investment rates in excess of 20% (tables 6.1 to 6.3), they accounted for the bulk of total investment in Ethiopian manufacturing during the 1996–2002 period. About 73% of total investment in machinery, 81% of investment in buildings and close to 90% of investment in vehicles occurred as lumpy investment. Taken together, establishments with investment spikes (13.6% of the total) accounted for 71% of total investment, underlining the importance of lumpy investment in capital adjustment. The extent of lumpiness is higher for buildings and vehicles than for machinery. On the other hand, peripheral investment accounted for only 18% of total investment in Ethiopian manufacturing. It is also clear from table 6.4 that investment by large firms is relatively less lumpy than that by small and medium-sized firms.

Lumpy investment also accounts for the lion's share of total investment in other countries. In the United Kingdom, Attanasio et al. (2000) found that 61% of total investment in buildings, 58.5% of investment in vehicles and 26.5% of in-

Table 6.4: Share of investment by investment rate categories (%)

	IR=0	0<IR=5%	5<IR=10%	10<IR=20%	IR>20%
Machinery					
Small		1.8	2.9	6.6	88.6
Medium		2.3	3.6	7.3	86.8
Large		7.7	8.1	16.8	67.5
Total		6.2	6.8	14.2	72.9
Building					
Small		4.1	2.0	6.4	87.5
Medium		5.5	2.2	10.2	82.0
Large		6.5	8.2	4.9	80.4
Total		6.1	6.4	6.2	81.3
Vehicle					
Small		0.5	1.3	1.1	97.1
Medium		0.4	1.8	4.3	93.4
Large		1.0	4.1	6.7	88.2
Total		0.9	3.8	6.3	89.0
Total Investment					
Small		4.0	4.6	10.3	81.1
Medium		4.4	5.5	8.3	81.8
Large		7.4	13.5	10.6	68.4
Total		6.7	11.7	10.2	71.3

Source: Author's computations based on CSA manufacturing census.

vestment in machinery was accounted for by just a few firms with lumpy investment. Irrespective of the type of investment, firms with investment spikes (5.4% of total) accounted for 24.6% of total investment in UK manufacturing. Similarly, Domes and Dune (1998) reported that firms with lumpy investment accounted for 25% of total investment in US manufacturing. While the importance of lumpy investment in overall capital adjustment is evident in developed countries as well, it is far less prominent than that observed in African manufacturing.

For the five sub-Saharan African countries mentioned earlier, Bigsten et al. (2005) showed that firms with lumpy investment (IR>20%) accounted for 47% of total investment, which is nearly twice the rate in the United Kingdom and the United States. The fact that the role of lumpy investment is much larger in Ethiopian manufacturing (accounting for 71% of the total), than in other sub-Saharan African countries reviewed here has more to do with differences in sample composition. The Ethiopian data is based on a manufacturing census that covers all firms employing at least 10 persons (and hence is dominated by small firms) while in the RPED data large firms are often over-sampled. As underlined by the preceding discussion, capital adjustment is relatively smoother among large firms.

6.3 Persistence of investment

Zero investment episodes need not necessarily be a problem unless they persist. One way of checking persistence in investment rates is to trace the one-year transition probability of investment rates. Table 6.5 provides such transition probabilities for investment in machinery and equipment for two sub-periods (the pattern for total investment basically reflects that of machinery). The table shows that zero investment episodes have a very high probability of being repeated in the next period. About 78.7% of firms with zero investment in machinery in any year during 1997–1999 had zero investment in the following year too. The likelihood of zero investment recurring in the next period is very high among small firms, at about 86%, declining to about 68% among medium-sized firms and to 60% among large firms. The tenacity of zero investment episodes actually increased during 2000 to 2002 except for a slight decline among small firms. Thus, not only is the proportion of firms with zero investment very high in Ethiopian manufacturing, the recurrence of zero investment conditional on zero investment in the current period has also increased.

Firms with non-zero investment in the current period are more likely to have positive investment in the next period. This does not apply for small firms, however, in which case more than half of those with positive investment in the current period showed zero investment in the next period. For instance, during 1997–1999, 80.7% of small firms with 0<IR<5% had a zero investment rate in the next period. The propensity to invest in the next period conditional on positive investment in the current period increases with firm size. Among medium-sized

Table 6.5: One-period transition probability of machinery investment rate

	1997–1999						2000–2002					
	IR=0	0< IR=5%	5<IR=10%	10<IR=20%	IR>20%	Total	IR=0	0< IR=5%	5 <IR=10%	10<IR=20%	IR>20%	Total
All Firms												
IR=0	78.7	8.8	3.5	2.5	6.5	100	80.5	7.9	2.7	2.7	6.1	100
0< IR=5%	43.7	34.9	4.0	6.4	11.1	100	36.7	32.0	8.2	8.2	15.0	100
5 < IR= 10%	30.0	27.5	10.0	10.0	22.5	100	40.7	15.3	13.6	15.3	15.3	100
10<IR=20%	27.7	29.8	2.1	10.6	29.8	100	40.0	30.9	12.7	5.5	10.9	100
IR>20%	31.9	20.2	10.1	12.6	25.2	100	43.7	16.0	9.2	12.6	18.5	100
Small												
IR=0	86.3	4.4	2.7	2.5	4.1	100	84.2	5.1	2.8	2.1	5.8	100
0< IR=5%	80.7	12.9	0.0	0.0	6.5	100	62.5	22.5	5.0	7.5	2.5	100
5 < IR= 10%	38.5	15.4	23.1	7.7	15.4	100	50.0	9.1	9.1	13.6	18.2	100
10<IR=20%	55.6	11.1	0.0	0.0	33.3	100	73.3	13.3	13.3	0.0	0.0	100
IR>20%	51.4	8.1	5.4	10.8	24.3	100	64.3	11.9	9.5	4.8	9.5	100
Medium												
IR=0	68.6	13.2	4.1	2.5	11.6	100	81.6	6.8	2.0	0.0	9.5	100
0< IR=5%	52.4	19.1	4.8	0.0	23.8	100	48.4	22.6	3.2	3.2	22.6	100
5 < IR= 10%	50.0	25.0	0.0	0.0	25.0	100	38.5	15.4	23.1	15.4	7.7	100
10<IR=20%	40.0	20.0	0.0	10.0	30.0	100	43.8	25.0	18.8	0.0	12.5	100
IR>20%	40.6	12.5	15.6	15.6	15.6	100	41.0	12.8	10.3	7.7	28.2	100
Large												
IR=0	60.2	21.7	6.0	2.4	9.6	100	62.0	22.8	3.3	9.8	2.2	100
0< IR=5%	25.7	48.7	5.4	10.8	9.5	100	18.4	40.8	11.8	10.5	18.4	100
5 < IR= 10%	6.7	40.0	6.7	20.0	26.7	100	33.3	20.8	12.5	16.7	16.7	100
10<IR=20%	14.3	39.3	3.6	14.3	28.6	100	16.7	45.8	8.3	12.5	16.7	100
IR>20%	12.0	34.0	10.0	12.0	32.0	100	23.7	23.7	7.9	26.3	18.4	100

Source: Author's computations based on CSA manufacturing census.

firms, for instance, more than half of firms with a positive investment rate in the current period were likely to undertake some investment in the next year. The transition from positive to zero investment declines substantially in the case of large firms, as they tend to invest more or less continuously.

There is also some persistence of lumpy investment, although it is far less tenacious than the zero investment episodes. Regardless of firm size, there was a 25% likelihood for investment spikes to recur during 1997–1999. Interestingly, about 30% of firms with investment rates between 10% and 20% were likely to have an investment spike in the next period. This shows that periods of large investment occur in close proximity just like periods of zero investment, although at a lower level of persistence.

However, the likelihood of having another round of high investment in the next period conditional on large investment in the previous period declined over the 2000 to 2002 period. Averaging across industries, persistence fell from 25% to 18%. This includes a sharp decline from 32% to about 18% for large firms and from 24% to just 10% for small firms. The slowdown of capital accumulation in Ethiopian manufacturing documented in figure 6.3 is therefore associated with the increase in the incidence of zero investment coupled with a decline in the recurrence of lumpy investment. It is interesting to note that the standard deviation of investment rate within a firm over time is 30% higher than the standard deviation of investment rate across firms at any point in time. This is to be expected given the increase in the incidence of zero investment episodes in parallel with a declining frequency of lumpy investment. Apart from its immediate impact on growth of manufactured output, poor investment performance would damage the competitiveness of the manufacturing sector, as the introduction of new products or new varieties of existing products often requires investment in new machinery and equipment.

Another way of exploring persistence is to see how often each firm invests during a particular time interval. Table 6.6 shows that on average 43% of small firms invested only once during the 1997–2002 period while another 30% invested twice. Few small firms (less that 5%) invested continually. On the other hand, 48% of

Table 6.6: Incidence of positive firm-level investment (1997–2002)

Counts of Positive Investment	Small (%)	Medium (%)	Large (%)	All Firms (%)
1	42.8	22.0	8.6	27.7
2	30.0	19.4	6.6	20.6
3	13.5	18.0	9.1	13.2
4	7.5	15.0	14.8	11.4
5	4.0	11.1	13.0	8.3
6	2.3	14.6	47.9	18.7
Total	100	100	100	100
Firm-Years	1501	768	950	3219

Source: Author's computations based on CSA manufacturing census.

large firms invested throughout the sample period, with less than 10% of them investing only once. Because of the predominance of small firms in the sample, nearly half (48.3%) of all manufacturing firms have positive investment for not more than two out of the six years. Other things being equal, the rate of investment is unlikely to increase as the size distribution of firms continues to shift to the left. There are no important industry-specific differences in this pattern.

Persistence, adjustment costs and irreversibility

What lies behind the discontinuity of capital adjustment documented so far? Theoretical models of investment assume that firms do not achieve their desired stock of capital for several reasons, including adjustment costs. Adjustment costs include but are not limited to output forgone during machine installation and costs arising due to the mandatory training of staff. Traditional investment models assume convexity of capital adjustment costs whereby the latter rise exponentially with the magnitude of adjustment. The implication of convexity is that firms would prefer to spread out their investment over time (in small lots) to avoid large adjustment costs. According to such models, we expect neither periods of zero investment nor investment spikes; capital adjustment would rather be smooth and continuous. Obviously, the adjustment patterns observed so far in Ethiopia and other sub-Saharan African countries do not conform to the predictions of convex adjustment costs. Neither does convexity fit capital adjustment patterns in developed countries (Caballero et al. 1995, Domes and Dunne 1998, Cooper et al. 1999).

Recent studies of investment behaviour pay a great deal of attention to irreversibility of investment and non-convexity of adjustment costs. Both features seem to have their own implications for capital adjustment patterns and some frameworks of analysis have been developed to learn their relative importance (Abel and Eberly 1994, Caballero and Engel 1999). If an investment decision is partly or fully irreversible because of missing markets for second-hand machinery, investors would be more cautious and wait for more information on expected returns before committing themselves to an investment project (Dixit and Pindyck 1994, Bertola and Caballero 1994). Given the possibility to delay investment outlays, waiting for more information allows investors to avoid costly mistakes in case an irreversible project turns unprofitable. Keeping open the option to productively invest in the future therefore has its own value,which becomes part of the opportunity cost of investment (exercising the option). This option value tends to increase with uncertainty, hence undermining investment by raising its opportunity cost. In such circumstances, there would be periods of inaction (zero investment or disinvestment) during which a firm does not respond to changes in desired stock of capital. While irreversibility seems to explain why there would be episodes of zero investment, it does not necessarily imply that once firms decide to invest their investment would be lumpy.

On the other hand, if adjustment costs are fixed rather than convex, firms would prefer to delay investment to avoid repeatedly incurring fixed adjustment costs (Caballero and Engel 1999). Fixed adjustment costs also imply that firms would prefer to invest in large amounts with intervals of zero investment. Such discontinuity of investment is therefore a rational response to increasing returns associated with fixed adjustment costs. Both irreversibility and fixed adjustment costs therefore seem to predict the actual capital adjustment patterns in sub-Saharan Africa better than quadratic adjustment costs.

While irreversibility and non-convexity of adjustment costs both predict zero investment, they differ in their implications for the propensity to invest conditional on current investment. In the case of irreversibility, the probability to invest in the next period is higher for firms that have positive investment in the current period as compared to firms with a current investment of zero. This follows from the assumption that a firm that decides to invest has sufficient information to resolve the uncertainty. Is this correct as edited?

In the language of duration analysis the hazard (probability) of investment follows a positive duration dependence if investment is difficult to reverse. In the case of fixed adjustment costs, however, the probability to invest in the next period is higher for firms with zero rather than positive investment in the current period. In this case, the hazard of investment follows a negative duration dependence (Cooper et al. 1999, Goolsbee and Gross 2000).

Although duration models offer the best way to investigate these phenomena, table 6.5 provides useful information to distinguish between irreversibility and fixed adjustment costs. Firms with zero investment in the current period were more likely to have zero investment in the next period, while firms with positive investment were more likely to have positive investment in the next period too. Firms with investment rates greater than the 10% depreciation rate have a particularly high propensity to have positive or even lumpy investment in the next period. This pattern is consistent with irreversibility and uncertainty rather than high fixed adjustment costs. Using duration analysis, Bigsten et al. (2005) found evidence in support of irreversibility although this evidence does not distinguish irreversibility from quadratic adjustment cost. Appendix 6.1 contains a further analysis of investment response to changes in the desired stock of capital.

6.4 Determinants of investment

Having looked at investment patterns, we now turn to investigate some of their determinants. The analysis starts by looking at what determines the decision to invest, as most firms in Ethiopia do not invest at any point in time. A binary choice model is used to analyse the probability of investment. Subsequently, a standard Euler equation is deployed to analyse variation in the investment rate.

Most empirical models address some elements of three major blocks of determinants of investment: quantity factors, price factors and shocks. For a review of standard investment models see Jorgenson (1971) and Chirinko (1993). The quantity factors often refer to changes in demand and access to finance. The former drives change in the desired stock of capital while the latter determines firms' ability to respond. Price factors, on the other hand, refer to capital goods prices, taxes and interest rates that affect the user cost of capital. Shocks include unobserved factors, such as idiosyncratic random shocks that are unknown to both the firm and the researcher and technology and productivity changes which are known to the firm but hard for the researcher to observe. They also include volatilities in quantity and price factors, which in principle are observable both to the researcher and the firm.

Although the main objective of investment models is to explain variation in the rate of investment, for African economies like Ethiopia, explaining the incidence of zero investment is important because of the prevalence of zero or practically zero investment rates. The dependent variable is therefore a dummy variable which takes the value 1 if the firm invests and 0 if not. The probability model to be estimated includes output growth and profit rate as explanatory variables representing changes in demand and the financial position of the firm. Unlike previous empirical studies, the probability model to be estimated also controls for firm-level efficiency. This allows us to assess the extent to which capital is being allocated toward efficient firms. The discussion in section 6.2 and earlier, in section 5.4, suggested that firm size is positively associated with the propensity to invest. The size effect often operates through quantity factors, particularly in relation to access to external finance. However, it may also work through productivity shocks arising from scale advantages or better access to technology. This study also includes firm age, industry and location effects to parameterise the model.

Compared to quantity and price factors, which have been researched extensively (albeit with limited success), emphasis on shocks as a potential determinant of investment began only recently. Irreversibility of investment decisions has received prime importance in recent theories of investment because of the value associated with the option of waiting which increases with uncertainty. This approach has two implications. The first is that uncertainty increases the rate of return that triggers investment if investment is hard to reverse. The traditional decision rule of undertaking investment when the net present value is at least zero is no longer applicable under irreversibility and uncertainty. The other implication is that irreversibility and uncertainty reduce firms' responsiveness to changes in the desired stock of capital. There will thus be a range of inaction (in terms of rates of return) within which the firm does not invest or disinvest.

Empirical studies are only gradually catching up with developments in theoretical models that deal with irreversibility and uncertainty. The main challenge in operationalising these investment models lies in measuring uncertainty and irreversibility. Most existing empirical studies use a panel of countries to assess the effect of uncertainty, which is often measured in terms of volatility of macroeconomic variables such as inflation, terms of trade and exchange rate. For a sample of

84 developing countries of which 40 are in sub-Saharan Africa, for instance, Serven (1997) found a significantly negative effect of macroeconomic volatility on investment. Similar results were reported by Hadjimichael et al. (1995) for a sample of 32 African countries. Carruth et al. (2000) provide a survey of the empirical literature on the effect of uncertainty on investment in developed countries and the overall message is that uncertainty has a negative effect on the rate of investment.

Econometric tests with firm-level data are even more scarce, and Pattillo (2000) was among the first to carry out such a test for an African economy. Based on RPED data for Ghanaian manufacturing firms, she measured uncertainty as the inter-firm variation (within an industry) in the one-year-ahead expected change in demand. The idea behind this approach is that a high degree of variation among firms regarding expectations of future demand would indicate high uncertainty. To capture reversibility, she used the information on whether a firm had leased a capital good, or sold or bought one from a second-hand market. She found a negative effect of uncertainty only for firms whose investments were irreversible. While interesting and innovative, this approach was criticised for its potentially serious mismeasurement of uncertainty and reversibility. In discussing Pattillo's (2000) contribution, Gunning (2000) argued that the real question regarding reversibility is not whether a firm actually leased or sold a capital item at a point in time; but whether it had the option to do so. Therefore, two firms investing in identical machines could be wrongly categorised as having different degrees of reversibility if one of them sold/bought a second-hand machine in the current period and the other did not. Regarding uncertainty, firms within an industry may expect, with certainty, widely different rates of change in demand for their respective products – in which case Pattillo's uncertainty measure would overstate the risk. In another extreme case, firms in an industry may expect demand shocks with little inter-firm variation, in which case Pattillo's measure would understate or even miss the uncertainty, since the standard deviation of expected change in demand would be close to zero (Gunning 2000).

To alleviate these measurement problems, this chapter follows a slightly different approach. The degree of reversibility of investment is approximated by the scope of the second-hand market in a four-digit industry. Assuming that this structural feature does not change rapidly over time (for which there is some evidence), the scope of the second-hand market is measured by the frequency of machine resale during the study period. The idea is that the higher the fraction of firms in an industry that engage in machine resale, the higher the possibility to reverse investment. In this case, even if a firm does not actually use the second-hand market, the existence of a functioning market increases the reversibility of investment and hence the propensity to invest. Three categories were identified: industries where the incidence of machine resale is less than 5%, between 5% and 10% and more than 10%. Dummy variables *Sechand1, Sechand2 and Sechand3* represent these categories, respectively, in the regression models. The decision of cut-off points is admittedly ad hoc and based on a visual inspection of the empirical distribution.

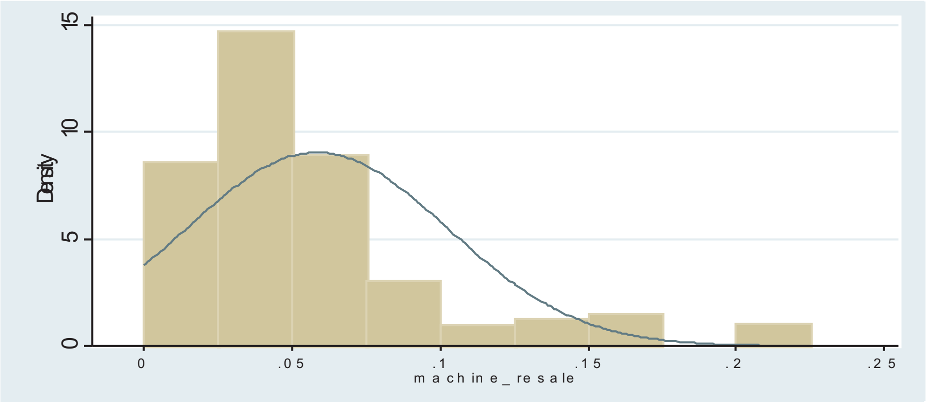


Figure 6.7: Frequency distribution of machine resale
Source: Author's computations based on CSA manufacturing census.

Figure 6.7 presents the distribution of machine resale representing the scope of the second-hand market. To measure uncertainty, a three-year moving standard deviation of sales and profit rates were calculated for each firm. The variables *Sales SD* and *Profit SD* represent volatilities in sales and profit, respectively. The assumption is that volatility in these variables would capture uncertainty. This measure is problematic since part of the movement in sales and profits could be the result of a conscious business decision rather than purely unexpected exogenous change. However, if a good part of the variation in profits is the result of deliberate actions by firms, then it should be positively associated with the rate of investment rather than displaying the expected negative relationship.

Table 6.7 reports the results of a probit regression model. The results indicate that change in the rate of profit does not significantly affect the likelihood of investment. This may seem odd but is consistent with our previous observation that most firms do not invest despite high profit rates. This is unlike Bigsten et al. (1999) which found that the propensity to invest increases with profitability. Interestingly, output growth and firm-level productivity are positively associated with the probability to invest after controlling for size, age and industry-specific effects. This underlines the importance of demand and relative efficiency in influencing propensity to invest. As expected, the probability model confirms the positive association between investment and firm size (measured as the logarithm of employment) as documented in the descriptive analysis. Older firms, on the other hand, are less likely to invest than young ones.

The results also show that the volatility of profit rate (*Profit SD*) has a statistically significant negative effect on the propensity to invest. Although profit rate may not induce firms to invest, its predictability seems to play an important role. Interestingly, reversibility, as captured by the scope of the second-hand market, increases the likelihood of investment. This effect is statistically significant in

Table 6.7: Probability of investment (Probit model estimates)

	Coefficient	Standard Errors
Profit Rate (t-1)	0.0159	0.0118
Output Growth (t-1)	0.0769*	0.0458
Productivity (t)	0.1101***	0.0392
Firm Size	0.6291***	0.0555
Firm Age	-0.0089**	0.0040
Profit SD	-0.0616*	0.0341
Sales SD	0.0000**	0.0000
Sechand 2	0.2333	0.1930
Sechand 3	0.7364***	0.2440
Sechhand2*Profit SD	0.0150	0.0390
Sechand 3*Profit SD	0.1002	0.1311
Sechhand2*Sales SD	0.0000*	0.0000
Sechand 3*Sales SD	0.0000	0.0000
Textile & Garments	-0.7790***	0.2480
Leather & Footwear	0.2470	0.2102
Wood & Furniture	0.0192	0.2218
Printing & Paper	0.6413***	0.1951
Chemical & Plastic	0.1873	0.1988
Non-Metal	0.1151	0.1889
Metal	0.0985	0.2474
Machinery	-0.4466	0.3651
Intercept	-2.5443***	0.2165
Wald Chi-square (p-value)	273.36	
sigma_u	0.8527	0.0706
Rho	0.4210	0.0404
Number of observations	2297	
Number of groups	698	

Note: Statistical significance at 1%, 5% and 10% are represented by ***, ** and *, respectively.

cases where the second-hand market involves more than 10% of firms *(Sechand3*). The interaction of reversibility with volatility of profits does not significantly reduce the negative effect of uncertainty. The coefficient of volatility of sales and its interaction with reversibility is practically zero. The main message from the probability model is that uncertainty in terms of volatile profits dampens the likelihood of investment while the existence of second-hand market tends to increase firms' willingness to invest. However, uncertainty's negative effect on investment is not significantly different across industries with varying degrees of reversibility.

The Euler equation

Models that explain the rate of investment traditionally come in two flavours: models with implicit dynamics and those with explicit dynamics (Chirinko 1993). The basic neoclassical model suggested by Jorgenson (1971) is typical of investment models with implicit dynamics. That model is based on a desired capital with the following structure:

$$K_t^* = \alpha Y_t C_t^{-\sigma} \quad (1)$$

where K_t^* is the desired stock of capital, Y_t is output (the quantity variable) and C_t is the cost of capital, which includes price variables such as interest rate, the price of capital goods and taxes, and σ is the elasticity of substitution between capital and variable inputs. The investment model is arrived at by splitting investment into net investment and replacement investment. As summarised in Chiriniki (1993, 1878), net investment is determined by the distributed lag on new orders which equal in a given period the change in the desired capital stock; replacement investment is determined by assuming a constant depreciation rate on initial capital.

$$I_t^n = \sum_{j=0}^{J} \beta_j \Delta K_{t-j}^* \quad (2)$$

$$I_t^r = \delta K_{t-1} \quad (3)$$

where I_t^n and I_t^r are net and replacement capital, β_j represents the delivery lag distribution over J+1 periods and δ is the depreciation rate. The neoclassical model is obtained by combining equation (1), (2) and (3) and adding a stochastic term:

$$I_t = \delta K_{t-1} + \sum_{j=0}^{J} \alpha\beta_j \Delta(Y_{t-j} C_{t-j}^{-\sigma}) + u_t \quad (4)$$

If the elasticity of substitution $\sigma = 0$, equation(4) reduces to the flexible accelerator model, although the basic neoclassical assumption is that $\sigma = 1$. Despite its popularity, the neoclassical models in (4) and other variants of it are criticised on several grounds (Chirinko 1993). Perhaps the most important critique relates to the distributed lags for net investment for which there is no theoretical foundation. Related to this is the static nature of expectations in neoclassical models which are based on extrapolation of past values of output and user costs. The firm in these models therefore does not need to look carefully into the future, which is incompatible with the forward-looking nature of investment decisions. Researchers, therefore, generally prefer investment models with explicit dynamics.

Models with explicit dynamics try to overcome this shortcoming by including the dynamic elements of the investment process directly into to the firm's optimisation problem. Tobin's *q* and the Euler equation are popular among these models. These models assume that firms maximise the discounted sum of expected cash flows subject to adjustment costs. In the *q* theory of investment, the unobserved expectation of future cash flows is related to observables based on the value of the firm in financial markets (Tobin 1969, 1978). While Tobin's *q* is a popular investment model partly because of the ease of obtaining stock market prices, its empirical performance has been disappointingly poor. Its application to developing country firms is also hampered by the absence of stock markets and the limited number of listed firms even where they do exist. Some of its assumptions, such as separation of the investment decision from financial decisions, are also untenable in the context of developing counties. For these two reasons this study follows the Euler equation approach, which has a limited (one year ahead) but forward-looking behaviour with convex adjustment costs.

The Euler equation is a structural model based on the following optimisation behaviour (Bond and Meghir 1994):

$$Y_t = F(L_t, K_t) \tag{5}$$

$$\Pi_t = p_t F(L_t, K_t) - p_t G[I_t, K_t] - w_t L_t - p_t^I I_t \tag{6}$$

where Y_t is output, $F(L_t, K_t)$ represents a production function homogenous of degree one, Π is gross profit, *L* and *K* are labour and capital, I_t is investment, p_t is output price, p_t^I is the price of capital goods and w_t is the wage rate.

Given a quadratic adjustment cost function of the form: $G[I_t, K_t] = \frac{1}{2} bK\left[\left(\frac{I}{K}\right) - c\right]^2$, a firm's objective is to maximise the following value function:

$$V(K_{t-1}) = \underset{\{K,L\}}{Max}\left\{\Pi(L_t, K_t, I_t) + \beta_{t+1} E\left[V_{t+1}(K_t)\right]\right\} \tag{7}$$

where β_{t+1} is the discount factor and *E* is the expectations operator. This objective function is subject to capital accumulation of the perpetual inventory approach:

$$K_t = I_t + (1-\delta)K_{t-1} \tag{8}$$

where δ is the rate of depreciation.

Maximisation of equation (3) yields the following investment model:

$$\left(\frac{I}{K}\right)_{t+1} = \beta_0 + \beta_1\left(\frac{I}{K}\right)_t - \beta_2\left(\frac{I}{K}\right)_t^2 - \beta_3\left(\frac{\Pi}{K}\right)_t + \beta_4\left(\frac{Y}{K}\right)_t + d_{t+1} + \eta_i + u_{t+1} \tag{9}$$

Three estimation methods are considered: the OLS estimator, the within estimator and the Generalised Method of Moments (GMM) estimator. Although the within estimator deals with firm fixed effects, the GMM estimator is the preferred method, as it deals more effectively with the endogeneity problem in the presence of the lagged dependent variable in the RHS (Arellano and Bond 1991).

Table 6.8 reports the regression results. Across all estimators, lagged investment has a positive and statistically significant correlation with current investment except for the within estimator, which yields a negative coefficient for medium-sized firms. This finding is in agreement with the persistence of investment documented earlier. According to the GMM estimator, which is the preferred estimator, profit rates are statistically significant only for investment by small firms. In the empirical literature on investment, profit rates are often interpreted as capturing the effect of financial market imperfection, while others (Bond and Cummins (2001) prefer to interpret them as a proxy for future profitability. If profit serves as an indicator of expected profitability rather than financial market imperfection, one would not expect heterogeneity in its effect

Table 6.8 : Estimates of Euler equation model, dependent variable is I_t / K_{t-1}

	Small			Medium			Large		
	OLS	**Within**	**GMM**	**OLS**	**Within**	**GMM**	**OLS**	**Within**	**GMM**
$\left(I_{t-1}/K_{t-2}\right)$	0.24874***	0.20854***	1.13399***	0.29425***	-0.16889*	1.19319***	0.47040***	0.159	1.518***
	(0.06087)	(0.06204)	(0.1027)	(0.072)	(0.08006)	(0.22089)	(0.06651)	(0.0835)	(0.213)
$\left(I_{t-1}/K_{t-2}\right)^2$	-0.06709**	-0.24491***	-0.63033***	-0.10452***	0.0212	-0.58488***	-0.14948***	-0.100**	-0.661***
	(0.02561)	(0.02665)	(0.04103)	(0.03043)	(0.03183)	(0.09637)	(0.0266)	(0.033)	(0.080)
$\left(\Pi_t/K_{t-1}\right)$	0.01027*	0.01793**	0.03490***	-0.01126	-0.04911***	-0.04352***	0.00507	-0.013*	-0.016
	(0.00471)	(0.00584)	(0.00782)	(0.00699)	(0.00847)	(0.01261)	(0.00516)	(0.006)	(0.009)
$\left(\Delta Y_t/K_{t-1}\right)$	-0.00092	-0.00632*	-0.01283**	0.00894***	0.03989***	0.04301***	0.00846***	0.030***	0.035***
	(0.00153)	(0.00303)	(0.00411)	(0.00248)	(0.00488)	(0.00731)	(0.00186)	(0.00324)	(0.005)
Constant	0.03225	0.09799***	0.00362	0.10350**	0.09233*	-0.02940*	0.08793**	0.02894	-0.006
	(0.02368)	(0.02364)	(0.00985)	(0.0339)	(0.03662)	(0.01424)	(0.03044)	(0.03469)	(0.013)
Sargan Statistic[a]			29.58181			27.928			47.40
Sargan p-value			0.000			0.000			0.000
No. Instruments			18			18			18
No. Observations	1140	1140	719	522	522	362	629	629	479
No. Groups		408	284		155	129		148	137
R-Square	0.025	0.204		0.0697	0.227		0.183	0.238	

Note: Statistical significance at 1%, 5% and 10% are represented by ***, ** and *, respectively. *a*: The p-value of the Sargan test rejects the restrictions on the instrument matrix of the GMM estimator which means that the instruments are not dealing with the endogeneity problem effectively. The same applies to the results in Table 6.9.

across firms of different size. The regression results, however, support the suggestion of imperfect credit markets where small firms rely more on their internal funds than medium and large firms. This is consistent with the findings of Tybout (1983) and Jaramillo et al. (1996) for Latin American countries and Bigsten et al. (1999) for sub-Saharan Africa. For medium and large firms, changes in output have a significantly positive effect, underlining the importance of demand factors.

The basic Euler equation is then extended by including indicators of uncertainty. This study uses the volatility of profit and its interaction with the scope of the second-hand market. Table 6.9 reports the GMM estimates of this extended model. The findings discussed earlier are unaltered by the inclusion of uncertainty and irreversibility: investment is path-dependent and small firms rely on internal funds more than medium-sized and large firms. The results show that uncertainty regarding future profits has a negative but insignificant correlation with investment. Therefore, uncertainty tends to influence the decisions on whether to invest rather than the level of investment. The interaction of uncertainty with the scope of the second-hand markets has a positive and statistically significant coefficient. This suggests that firms that have more options to reverse their investment have higher rates of investment for a given level of uncertainty. This result does not hold when the regression is restricted to medium-sized and large firms.

Table 6.9: GMM estimates of investment under uncertainty

	All Firms	Small	Medium	Large
$\left(I_{t-1}/K_{t-2}\right)$	1.4693***	1.1440***	1.2885***	1.5474***
	(0.1006)	(0.1047)	(0.2337)	(0.2135)
$\left(I_{t-1}/K_{t-2}\right)^2$	-0.7156***	-0.6327***	-0.6322***	-0.6851***
	(0.0400)	(0.042)	(0.1023)	(0.0810)
$\left(\Pi_t/K_{t-1}\right)$	0.0012	0.0347***	-0.0441***	-0.0157*
	(0.0057)	(0.0079)	(0.0129)	(0.0094)
$\left(\Delta Y_t/K_{t-1}\right)$	0.0113***	-0.0126***	0.0428***	0.0293***
	(0.0033)	(0.0042)	(0.0076)	(0.0057)
Profit SD	-0.0121	-0.0057	-0.0530	-0.0035
	(0.0147)	(0.0156)	(0.0335)	(0.0385)
Sechand2 * Profit SD	0.0146	0.0028	0.0550	0.0312
	(0.0176)	(0.0205)	(0.0363)	(0.0448)
Sechand3 * Profit SD	0.0933***	0.3524*	0.0950	0.0599
	(0.0248)	(0.2156)	(0.0901)	(0.0451)
Intercept	-0.0127*	0.0012	-0.0318**	-0.0021
	(0.0072)	(0.0098)	(0.0141)	(0.0126)
Sargan Statistic	62.1200	63.0500	23.0600	39.6900
Sargan p-valuea	0.0000	0.0000	0.0060	0.0000
M1 (p-value)	0.0000	0.0000	0.0000	0.0000
M2 (p-value)	0.5190	0.2670	0.6870	0.1510
No. Observations	1537	838	360	478
No. Groups	539	265	128	137

Note: Statistical significance at 1%, 5% and 10% are represented by ***, ** and *, respectively.

6.5 Investment, productivity and innovation

Having looked at the patterns of capital adjustment and its key determinants, it is now time to explore the interdependence between capital formation, relative efficiency and innovativeness. This will provide insight into the consistency of firm-level capital accumulation with the process of market selection as well as with accumulation of technological capabilities.

6.5.1 Investment and productivity

How does investment relate to productivity? The market selection literature suggests that firms respond to a positive productivity shock with investment. In fact, theories of market selection are essentially dynamic theories of investment. Figure 6.8 shows a bivariate non-parametric regression of investment rate on firm-level productivity. The regression line plots the conditional mean investment rate using the Nadaraya-Watson kernel estimator. The graph shows that investment increases with firm-level efficiency in a non-linear fashion. This indicates that efficient firms are in a better position to take advantage of investment opportunities arising in an industry. Given the persistence of relative efficiency documented in the transition matrices in Chapter 3 (table 3.3), the positive relationship between investment and efficiency suggests the tendency for capital to be concentrated among highly productive firms. This is consistent with the finding in Chapter 3 (table 3.3c) that manufacturing employment also tends to be concentrated among efficient firms.

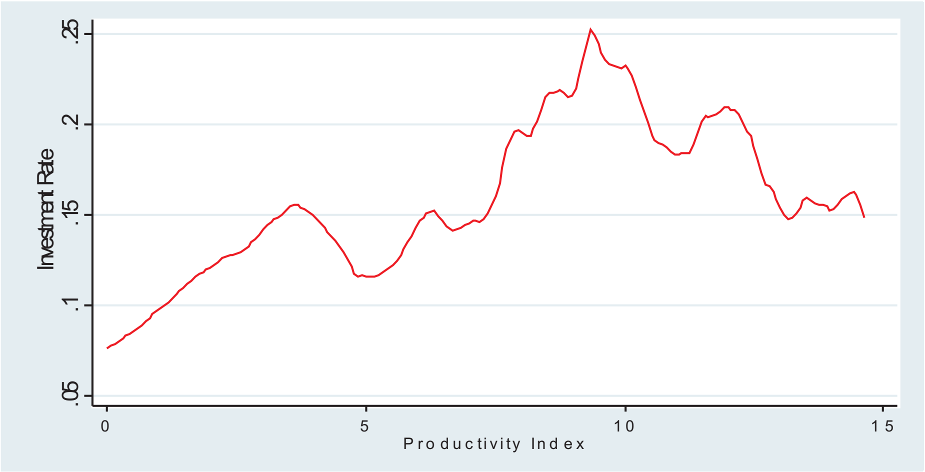


Figure 6.8: Investment and productivity in Ethiopian manufacturing (1997–2002), Nadaraya-Watson non-parametric regression

Source: Author's computations based on CSA manufacturing census.

The evidence in figure 6.8 is supported by the statistics in table 6.10. The table compares the productivity raking of firms in 1997 with their subsequent investment rates. The table shows that the fraction of firms with investment spikes increases with firm efficiency. Among firms in the top productivity quintile in 1997, nearly one-quarter (23.7%) had investment spikes in subsequent years, and this fraction declines to less than 10% in the bottom quintile. In contrast, 64% of firms in the bottom quintile in 1997 had zero investment in the ensuing years, with this proportion declining steadily to about one-third among firms in the top quintile. Interestingly, most entrants since 1997 had zero investment up to 2002. Productive firms were therefore more likely to have investment spikes, while inefficient firms were more likely to have zero investment episodes. Also, apparently entrants were not investing aggressively, consistent with such firms being relatively small in size and of uncertain position in the market.

What about the impact of investment on productivity? Figure 6.9 shows that investment lagged by one period has a positive relationship with current productivity, although the productivity effect is less pronounced for extremely high investment rates. Current productivity thus provides a signal for desired investment while current investment raises future productivity.

Table 6.11 provides additional evidence on the relationship between investment and productivity. Perhaps the most consistent and interesting observation from the table is that the fraction of exiting firms declines steadily with the rate of investment. Among firms with lumpy investment in 1997 only 14% exited the market before 2002 while the corresponding exit rate among firms with zero investment is 47%. This indicates that investment tends to increase the survival probability of firms as was shown in the survival analysis in Chapter 4. The message is not so clear at the top of the productivity distribution. About 31% of firms with lumpy investment in 1997 were found in the top productivity quintile in 2002, compared to 14% of the firms with zero investment. About 30% of firms with a positive but less than 5% investment rate were also observed in the top quintile in 2002 blurring the relationship between investment and relative efficiency. Further investigation, however, reveals that these are large firms that

Table 6.10: Distribution of investment rate by productivity ranking

Productivity Quintiles in 1997	IR>20%	10<IR=20%	5<IR=10%	0<IR=5%	IR=0	Total (%)
1	23.7	10.6	9.9	23.2	32.6	100
2	14.3	8.6	8.2	19.9	49.1	100
3	12.3	5.5	7.2	20.0	55.0	100
4	12.2	6.9	6.0	15.6	59.3	100
5	8.5	4.3	4.8	18.0	64.4	100
Entry	9.1	4.7	4.4	20.3	61.6	100

Note: Number of observations is 3,431 firm-years. Numbers add up to 100 row-wise.
Source: Author's computations based on CSA manufacturing census.

Table 6.11: Initial investment and subsequent productivity ranking

Investment in 1997	Productivity Quintiles in 2002					Exit	Total
	1	2	3	4	5		
IR>20%	30.8	22.0	18.7	8.8	5.5	14.3	100.0
10<IR=20%	34.2	26.8	14.6	2.4	2.4	19.5	100.0
5<IR=10%	3.9	26.9	23.1	15.4	3.9	26.9	100.0
0<IR=5%	30.3	14.5	11.8	7.9	6.6	29.0	100.0
IR=0	13.9	11.9	11.2	7.7	8.5	46.9	100.0

Note: Number of observations is 494 firms.
Source: Author's computations based on CSA manufacturing census.

likely have other sources of efficiency. The general message is that firms that do not invest are more likely to exit. This could be either because lack of investment reduces the relative efficiency of firms, subsequently leading to exit, or because firms that realize that they are relatively inefficient refrain from investing and continue to operate until the time is right to close down.

6.5.2 Investment and innovation

Chapter 5 on technological capabilities revealed that few firms engage in building technological capabilities. For such innovative firms, building technological capabilities is accompanied by productivity gains and increased prospects for growth. The literature on technological capabilities asserts that firms need these capabilities to utilise existing technology at a best-practice level of efficiency and also to continually upgrade. The need for technological capabilities is particularly acute for firms trying to introduce new products or new varieties of existing products, compared to firms merely expanding production capacity for the same product. This implies that a lack of technological capabilities may restrain firms from investing in new products, hence limiting growth prospects.

This section explores the link between investment behaviour during 1997–2002 and technological capabilities for a sample of firms surveyed in 2004. If technological capabilities constitute a binding constraint on firms' desired investment, especially for new products, we would expect firms with high technological capabilities to invest more often than non-innovative firms.

Figure 6.10 provides some evidence along these lines. The figure collapses the five clusters of technological capabilities identified in Chapter 5 into three: the first one (High) includes the relatively innovative Cluster 1, which is made up of firms that engage in most of the technological capabilities discussed earlier; the last cluster (Low) includes the non-innovative Cluster 5, which is made up of firms engaging in either none or only few of the technological capabilities. The middle category (Moderate) combines the three clusters that fall in-between, i.e., clusters 2, 3 and 4. The graph also compares the results based on two different methods of clustering. It shows that the incidence of zero investment is more prevalent among non-innovative firms and declines substantially among innovative firms. In both methods of clustering, the share of firms with zero investment among non-innovative firms is three times higher than that of (relatively) highly innovative firms. On the other hand, innovative firms are more likely to have investment spikes than non-innovative firms. This suggests that innovation enhances the productivity of manufacturing firms, which in turn increases the likelihood of high investment. Investment in turn leads to productivity growth with a lag as shown in figure 6.9. The nature of this data and analysis does not allow us to resolve the simultaneous causation among these variables. However, the observed interdependence explains the forces behind the persistence of relative efficiency at the top of the productivity distribution documented in table 3.3a of Chapter 3. It underscores that innovation enhances efficiency and that more efficient firms are more likely to invest, leading in turn to productivity growth even for non-innovative firms. It also indicates that the process of capital accumulation is consistent with the market selection process. While the interdependence between selection, investment and innovation is evident and healthy, the latter two occur so sparsely that it is inconceivable for sub-Saharan Africa to achieve industrial competitiveness without this being resolved.

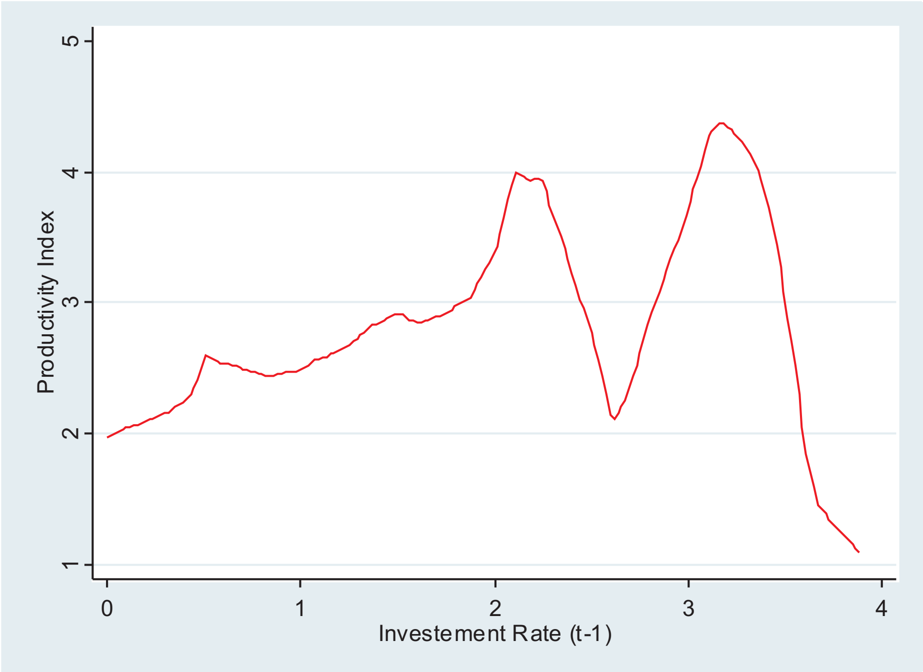


Figure 6.9: Productivity and investment in Ethiopian manufacturing (1997–2002), Nadaraya-Watson non-parametric regression

Source: Author's Computation Based on CSA's Manufacturing Census

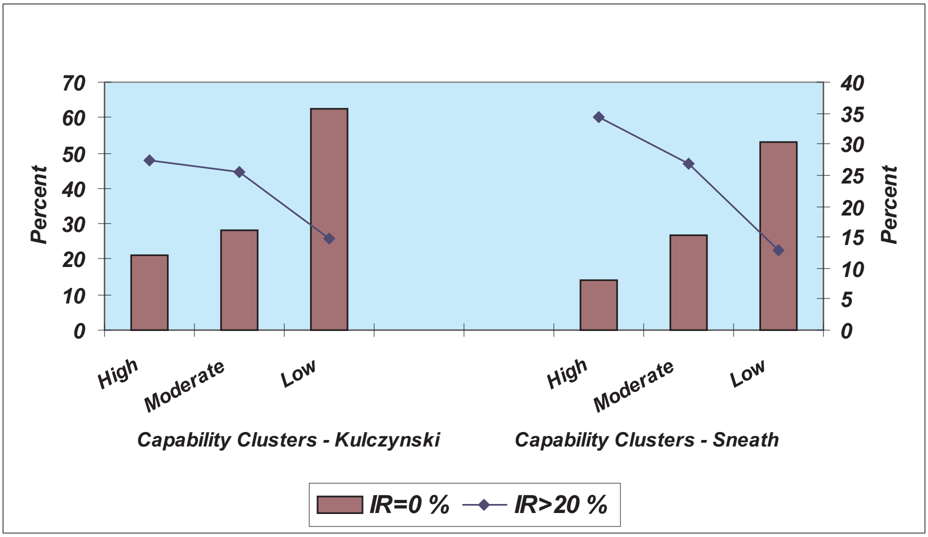


Figure 6.10: Investment and technological capabilities in Ethiopian manufacturing
Source: Author's sample survey and CSA manufacturing census.

6.6 Conclusions

Like other sub-Saharan African countries, high profit rates in Ethiopian manufacturing do not translate into high investment rates; at least not in the same establishment. Episodes of zero investment were observed in more than half of the manufacturing establishments at any point during the study period. Capital adjustment took place mainly in the form of large discrete jumps rather than through smooth increments. As a result, more than two-thirds of total investment across industries was accounted for by the lumpy investment of a few establishments. The rigidity of capital adjustment was most severe among small firms, among which the incidence of zero investment was rampant.

Adjustment patterns in Ethiopia are very similar to patterns in other sub-Saharan African countries except for differences arising from size composition of samples. While investment of firms in a sample of European countries also shows lumps and bumps, its discontinuity is far less than that observed in Africa. African firms reviewed in this chapter invariably showed profit rates several times higher than their European counterparts, although their investment performance was disproportionately low. Uncertainty and the difficulty of reversing investment decisions play key roles in dampening firm-level investment in African manufacturing. The prevalence and persistence of zero investment documented in the one-period transition probability is consistent with the pattern of capital adjustment (or lack thereof) expected under uncertainty and irreversibility. Regression results reveal the probability of investment to be higher in industries with a broader second-hand market. Similarly, uncertainty arising from volatility of profits has a negative influence on the propensity to invest, though the level of profits itself is less important. Uncertainty, however, seem to have no significant effect on the rate of investment, while firms with options to reverse their investment are shown to have higher investment rates.

The level of profit has a positive and significant effect on investment among small Ethiopian firms, a common observation in most developing countries. The standard interpretation that small firms rely more than large firms on internal funds for investment also seems to apply here. Such imperfection in financial markets and the need for small firms to accumulate sufficient internal funds coupled with the indivisibility of capital items provide an additional explanation for the sharp discontinuity of investment among small firms. The obvious policy implication is to improve the accessibility of modern financial services to small businesses. Private-sector borrowing from the banking system in Ethiopia however has been declining in recent years. The drop in credit flow to the private sector has much to do with recent developments in the political economy of the country as documented in Chapter 2. Policy moves such as the introduction of the Bank Foreclosure Law and the Anti-Corruption Law were followed by sharp declines in credit to the private sector, demonstrating the sensitivity of the investment climate to such measures. The downside of such swift and apparently legitimate policy measures is that they signal an uncertain and uncooperative business-government relationship. The result is a decline in the aggregate investment rate underpinned by an increase in the incidence of zero investment and a decline in the incidence of firms with an investment spike. Therefore, while inter-firm and inter-industry differences in irreversibility and volatility of profits may explain firm level variation in investment, the time path of aggregate capital accumulation seems to be driven by broader developments in the political economy.

Another important empirical regularity documented by productivity analyses in developed and developing counties is the persistence of efficiency at the top of the distribution. This chapter went further to show some of the reasons for such persistence. The fact that productivity increases the likelihood of investment and investment in turn boosts efficiency with a lag enables efficient firms to retain their relative position. On the other hand, innovation not only enhances efficiency, innovative firms also take advantage of their competitive edge by accumulating more capital. This interdependence between efficiency, investment and innovation keeps efficient firms at the top of the productivity distribution. Most exiting firms, on the other hand, are not only inefficient, but they also fail to invest. If inefficient firms do not invest because they are conscious of their inefficiency, their exit would enhance aggregate efficiency, as capital is reallocated to more efficient producers. However, when small entrants fail to invest because of financial constraints or when uncertainty discourages incumbents from investing, the resulting loss of efficiency reduces aggregate productivity and leads to the exit of potentially successful businesses. This study finds evidence of an investment process that is losing momentum over time but is still consistent with market principles. The policy implication is therefore to maintain the functionality of markets to ensure efficient allocation of resources while reducing financial imperfections and business uncertainty to induce firms to invest and innovate. Sensitivity to the implications of policy changes for business confidence is particularly important, as bold steps are as likely to create uncertainty as tentativeness in taking action.

Appendix Chapter 6: Desired capital and investment

Further analysis was carried out to assess firm response to changes in the desired stock of capital. In line with the approach suggested by Caballero, Engel and Haltiwanger (1995), mandated investment was calculated as the difference between desired and actual capital stock.

$$\text{MI} = k_{it}^{\sim} - k_{it-1} \tag{1}$$

where MI is mandated investment, and $k_{it}^{\sim}$ and k_{it-1} are the log of desired and actual capital. Following Caballero et al. (1995) desired capital is assumed to be a certain proportion of frictionless capital k_{it-1}^{*}:

$$k_{it}^{\sim} = k_{it}^{*} + d_i \tag{2}$$

where d_i is a firm or industry-specific constant.

The frictionless capital k_{it}^{*} is determined using user cost of capital and output as in the standard neoclassical approach. This gives the following expression:

$$k_{it}^{*} = k_{it-1} + \eta_i \left[(y_{it} - k_{it-1}^{*}) - \theta_i c_{it} \right] \tag{3}$$

where $\eta_i = 1/_{1-\alpha_i}$ is the slope of the profit function with respect to capital and α_i is the cost share of equipment capital.

$$c_{it} = \frac{(r+\delta_i)\left(PI_t / P_{it} \right)}{(1-\tau)} \tag{4}$$

where r the real lending rate (lending rate minus inflation), δ_i is the depreciation rate, PI_t is the price index of capital goods, p_{it} is the firm-specific price index and τ is the profit tax rate. In this exercise, PI_t is approximated by the unit price of machinery imports to Ethiopia assuming that the composition of machines imported to the country and their technological content remained stable during the study period. Once c_{it} is calculated, then θ_i are estimated from a regression of the natural logarithm of capital-to-output ratio on cost of capital and the coefficient of c_{it} is interpreted as the long-run elasticity of capital with respect to the cost of capital. This was done separately for each industry and the elasticities were found to be negative and statistically significant. Finally desired capital was estimated by adding a constant d_i to frictionless capital, which in this case is the industry-specific median investment rate. Note that desired capital is the capital the firm wants to have if there are no adjustment costs, while frictionless capital is the capital the firms desires if adjustment costs are temporarily removed.

The actual investment rate was then regressed against mandated investment using the Nadaraya-Watson kernel estimator following the approach in Goolsbee and Gross (2000). Caballero and Engel (1999) suggest that in the presence of fixed adjustment cost, average investment increases with mandated investment in a non-linear fashion with a range of inaction at the lower level of discrepancy between desired and actual capital. Under irreversibility, Bigsten et al. (2005) showed that the relationship between actual and mandated investment is linear outside the range of inaction. The resulting relationship for Ethiopian manufacturing is given below.

Figure A6.1 shows the Nadaraya-Watson kernel regression of investment rate on mandated investment. The graph does not show a range of inaction expected under irreversibility and fixed adjustment costs. However, it does indicate that firms respond to large discrepancies between desired and actual capital in a non-liner fashion which would be the case under fixed adjustment costs.

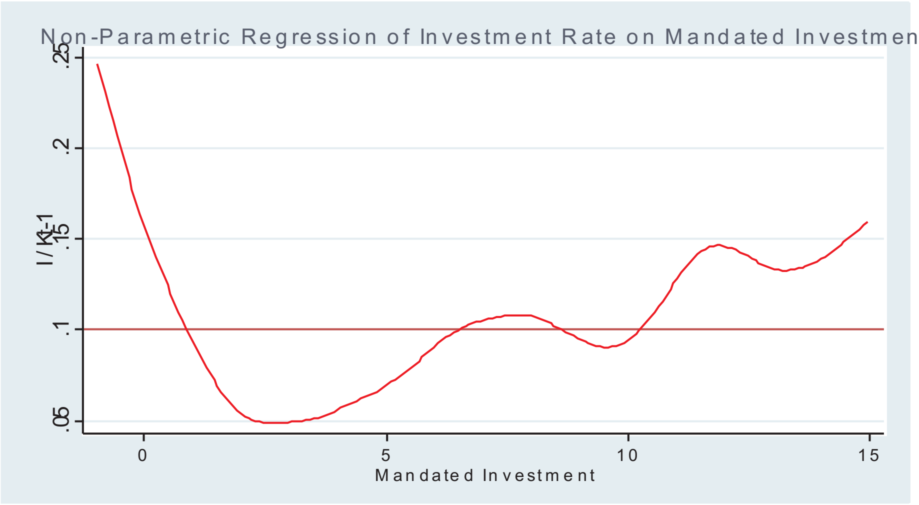


Figure A6.1 Nadaraya-Watson kernel regression of investment rate on mandated investment
Source: Author's computations based on CSA manufacturing census.

Notes to Chapter 6

1. This is why the median investment rate was zero in another study, which included only four of the five countries (Bigsten et al. 1999).

7 Summary and Conclusions

This thesis argues that industrial competitiveness in sub-Saharan Africa can better be explained through closer investigation of the processes of market selection, accumulation of technological capabilities and investment. The analysis shows that markets in sub-Saharan Africa, as represented by Ethiopia, are at least as functional as elsewhere in selecting efficient firms. Moreover, exposure to international competition tends to reduce tolerance to inefficient firms and hence sharpens selection. Productivity transition matrices reveal that efficient firms in Ethiopian manufacturing tend to stay at the top of the productivity distribution while inefficient firms are forced to close down. This pattern of firm dynamics is consistent with the findings of Baily et al. (1992) for US manufacturing, except that turnover rates are relatively higher in Ethiopia. The market selection process has contributed to aggregate productivity growth as well, mainly through reallocation of resources from less to more efficient incumbents and to a lesser extent through producer turnover. The contribution of the reallocation effect is comparable to that observed by Baily et al. (1992) and Bernard and Jensen (1999) for the United States while it differs from the findings of Aw et al. (2001) for Taiwan and of Liu and Tybout (1996) for Colombia, where industry rationalisation played no significant role in aggregate productivity growth. On the other hand, producer turnover and its contribution to industry-level productivity in Ethiopia is well below that found by Aw et al. (2001) for Taiwan but higher that that reported by Baily et al. (1992) for the United States. This difference in the role of producer turnover is due to the major part played by entrants (and the introduction of new products with them) in the rapid expansion of Taiwanese manufacturing, as compared to the mature US manufacturing industry, where entry and exit cohorts account for a very small share of industry-level output and display narrow productivity differences . The Ethiopian case seems to fall in-between, with entrants and exiting firms showing no substantial productivity differences but with recent entrants collectively accounting for one-quarter of the market. All of these observations suggest that African manufacturing meets the basic requirements of competitiveness, whereby resources and market shares are allocated through a competitive process. This conclusion corroborates the claim by some authors that African countries qualify as market economies in view of the sheer frequency of market-based transactions and the numerous entrepreneurs, including those in the informal sector (Fafchamps 1997,2004). It can be concluded that problems in African manufacturing are not so much related to entry barriers, such as large sunk entry costs or collusion of large incumbents, the latter of which is easier in small markets. Rather, the real challenge for most African entrants is to survive, gain efficiency and grow. For instance, the rigidity in the size distribution of African manufacturing firms reflects the fact that most firms are born small and remain small while the few large firms were born large (Van Biesebroeck 2005, Liedholm and Mead 1999).

Our confidence in markets as a source of productivity improvements arises from the assumption that competition forces inefficient firms either to close down or to raise their efficiency by adopting better technologies and reducing slack and waste. However, the most common outcome among inefficient firms in Ethiopia is to exit the market rather than to upgrade their relative efficiency through innovation. A comparison of productivity dynamics, for instance, shows that firms in the lowest productivity quintile in US manufacturing, as reported by Baily et al. (1992), are twice as likely as their Ethiopian counterparts to raise their relative productivity rankings. This suggests that developed countries, more than their developing counterparts, offer entrants (which are often small and located in the lowest productivity quintile) better chances of growth in terms of size and efficiency. Other researchers have also reported higher rates of producer turnover in developing countries compared to developed countries (Roberts and Tybout 1996, Aw et al. 2001). Better chances for survival and productivity growth for entrants have to do, among other things, with the high average skill levels in the labour market and with the well developed technological infrastructure and business support services in industrialised economies, all of which are severely lacking in least developed countries. It is unsurprising, therefore, to observe African markets that operate smoothly in ensuring efficient allocation of resources but do not guarantee aggregate productivity growth or even prevent declines in aggregate productivity. During the 1996–2002 period, TFP in Ethiopian manufacturing fell by about 5% per annum. Our productivity decomposition analysis revealed this to be entirely due to dwindling intra-firm productivity. A review of similar literature by Bartelsman and Doms (2000) shows the intra-firm effect to be the major driver of aggregate productivity growth in advanced countries. Obviously competitiveness requires more than functioning markets and efficient resource allocation. The current study therefore went further to investigate two intra-firm activities, namely innovation and investment, to better understand the forces behind the observed productivity dynamics and long-term competitiveness.

This study shows that accumulation of technological capabilities enhances firm-level productivity, presumably by enabling firms to use existing technologies and resources more efficiently, as the TC approach claims. Innovation also constitutes part of a business growth strategy, as firms accumulate technological capabilities in anticipation of expansion. These results are consistent with the findings of Teitel (2000) and Wignaraja (2002) for Zimbabwe and Mauritius, respectively, while showing the important role that technological capabilities can play even when the manufacturing sector is not export-oriented, as currently is the case in Ethiopia. The fact that firms investing primarily to introduce a new product or a new variety of an existing product are more likely to face skill shortages than those investing primarily to expand capacity for an existing product also indicates the potential constraint that technological capabilities could exert on investment. Further analysis confirmed this by showing that innovative firms were more likely to have lumpy investment patterns, while non-innovative firms were more likely to have zero investment episodes.

These economic phenomena are more than the efficient allocation of resources among existing products; they shed light on a key aspect of industrial progress, which is associated with the introduction of new and better quality products. The importance of that last has been re-emphasised in a new crop of empirical research which uses highly disaggregated country-level export data. Klinger and Lederman (2004), for instance, showed economic growth to be strongly associated with the introduction of new items in the export basket of a country and this process of "discovery" (as the authors refer to it) follows an inverted U shape when plotted against per capita income. This is similar to the U-shape relationship that Imbs and Wacziarg (2003) discovered when observing the nature of the relationship between an indicator of sectoral concentration and per capita income. Both contributions underscore the crucial role of discovery and diversification in economic growth. In this regard, Hausmann and Rodrik (2006: 37) suggest, 'In the process of development, countries need to not only increase output per worker in existing activities, but also to transfer resources to higher productivity activities.' The firm-level analysis of technological capabilities in this study, as well as the stylised facts from recent studies that use disaggregated export data, underline the critical role that innovation could play in industrial competitiveness in sub-Saharan Africa. This potential role has been downplayed by the neoclassical assumption of costless and immediate transfer of technology and by structural adjustment programmes which focus more on trade liberalisation and macroeconomic stability.

While the link between innovation and firm performance is fairly clear, the majority of Ethiopian manufacturing firms do not accumulate technological capabilities. The distribution of an aggregate TC index in Ethiopia manufacturing exhibits a positive skew, revealing a scarcity of innovative activities. The low incidence of innovation is by and large a reflection of the size distribution of manufacturing firms in Africa, in which small firms dominate. Indeed, small firms were shown to be far less innovative than their medium-sized and large counterparts. The literature suggests that this is mainly because of the ability of large firms to spread the costs of innovation over a large volume of output and the division of labour in large firms, which facilitates specialisation and innovation. The positive association between innovation and firm size implies that the accumulation of technological capabilities in African manufacturing is bound to deteriorate if the size distribution continues to shift to the left, as witnessed in Ethiopian manufacturing during the study period. This goes some distance in explaining the observed intra-firm productivity decline during the study period and why exit is the least costly option for most of the inefficient firms in Africa, rather than upgrading through innovation. The low incidence of technological capability accumulation also implies a loss of competitiveness for African manufacturing, as it fails to tap into the fast-growing market for knowledge and technology-intensive products. This view is supported by findings of Hausmann et al. (2005) and Hausmann and Klinger (2006), which reveal that exporting technologically advanced products is a statistically significant predictor of future economic growth. In other words, shifting the product mix toward that of advanced counties is the best way to promote growth in developing countries. In the words of Rodrik (2006: 11), 'Poor countries remain poor because they are not producing the kind of goods that will carry them towards riches.'

Another reason for the slow pace of technological capability accumulation is perhaps the associated externalities and market failure. Although this study does not provide direct evidence in this regard, research elsewhere indicates that the indirect effect of innovation on the performance of non-innovators (the spillover effect) is at least as strong as the direct effect on innovators (Fagerberg 1996). This has also been the main assumption of endogenous growth models. Such externalities constitute market failure and justify policy interventions to achieve optimal outcomes. The low level of human capital and poor technology infrastructure in countries like Ethiopia imply very high costs for firms to bring their skills and competences to levels comparable to those in developed countries or even leaders in the developing world. Such high costs plus the associated externalities and risk reduce the incentive and ability of African firms to build technological capabilities. Putting in place industrial policies that take account of such market failures could therefore play a key role in stimulating industrial competitiveness in the region. The exact nature of the capabilities that need to be built, however, is hard to pin down because of their specificity. As pointed out by Rodrik (2006: 24), developing country governments do well to refrain from a top-down choice of activities and instruments. What is needed is to create a space for a productive public-private partnership that would generate the information needed to identify viable activities and suitable interventions. Unfortunately, the public-private partnership in Ethiopia and presumably that in other sub-Saharan Africa countries, like Zimbabwe for instance, has recently been rocked by several instances of misunderstanding and abrupt policy changes that undermine the formulation of effective industrial policy.

Investment in physical capital is another intra-firm activity analysed in this study in connection with industrial competitiveness. Here, as with the findings related to technological capabilities, the results indicate disappointing performance. The share of firms with positive investment as well as the rate of investment in Ethiopian manufacturing declined during the study period. Research in other African counties (Bigsten et al. 1999, 2005) has found even higher incidences of zero investment, which is consistent with the poor performance of the region's manufacturing in terms of contributions to GDP and world exports. In addition to confirming the investment patterns observed in other African countries, this study found that capital accumulation in Ethiopia is consistent with market principles, as efficient and innovative firms tend to invest more often and at higher rates than inefficient and non-innovative firms. Firms that invest also tend to gain productivity in subsequent years while non-investing firms are more likely to exit the market. Such an interrelationship between efficiency, investment and innovation perpetuates relative efficiency, implying that it is a major force behind the persistence at the top of the productivity distribution – an important stylised fact in developed and developing countries alike but one that has never before been given an explanation.

Despite this expected and healthy interdependence between efficiency, innovation and investment, capital accumulation is slowing in Ethiopia and in other African countries. This is surprising given the reduction in foreign exchange constraints and import tariffs in these countries. The poor state of technological capabilities is likely to have played a role, as it undermines firms' ability to take up investment opportunities. One of the problems mentioned by firm managers in Ethiopia is, for example, the lack of qualified technicians who can maintain and repair sophisticated machines. However, examination of capital adjustment patterns and regression analysis suggest that uncertainty is perhaps the most important factor behind inadequate investment. This study found evidence that uncertainty in terms of volatile profits reduces the likelihood as well as the rate of investment. Building upon the methodology suggested in Pattillo (2000), irreversibility of investment, captured by the scope of the second-hand market for machines, also reduces the likelihood of investment, although it does not magnify the effect of uncertainty. While Ethiopia's macroeconomic indicators appear fairly stable, the uneasy developments in the political economy of the country must have dampened the readiness of banks and investors to undertake investment projects. Since 1997, credit flows to the private sector and investment in manufacturing have been in a downward spiral, while banks continue to be flooded with excess liquidity. Part of the productivity decline in Ethiopian manufacturing is therefore related to the decline in capital accumulation, which has a lot to do with the uncertainty of the business environment.

The output growth observed in Ethiopian manufacturing during the study period (figure 2.1) was therefore mainly driven by the high rate of entry rather than expansion through innovation and investment by incumbents. While entrants played a critical role in Asian economies as well, their importance in the latter went hand-in-hand with rapid industrialisation and changes in the industrial composition of manufacturing (Aw et al. 2001). In the Ethiopian context though, high entry rate is not associated with change in industrial composition; rather, it reflects the uncertainty facing entrepreneurs. This is evident from the extraordinarily high average profit rates in Ethiopia and other African countries compared to those in European countries. A high entry rate in the face of a relatively low and declining rate of investment by incumbents suggests that investors prefer to diversify risk by opening other small businesses rather than ploughing back their profits to enlarge an existing firm – a conclusion shared by Fafchamps (1997). This may be a rational choice from an investor's point of view in the presence of uncertainty but it undermines competitiveness at the aggregate level. The fact that small firms are less likely to innovate and invest implies that African manufacturing faces a high risk of remaining uncompetitive if current trends prevail.

On the other hand, firm growth regressions suggest that small firms tend to grow faster than large ones, in conformity with models of industrial evolution and empirical studies for other countries (Evans 1987 a,b, Hall 1987). Nonetheless, a number of factors make a growth strategy based on small firms unattractive for African economies. Small firms are less likely to survive, which means that their growth may not contribute much to the expansion of an industry. Growth of small firms, at least in Ethiopian manufacturing, also seems bound from above, as few small firms graduate to become medium-sized and none grew to the large size category over a six-year period. Furthermore, the primary purpose of investment by small firms, if investment occurs at all, is to expand capacity for an existing product rather than to introduce a new product or a new variety of an existing product. For medium-sized and large firms, however, investment is primarily associated with the introduction of new products or new varieties. This is obviously related to differences in the technological capabilities needed to introduce new items. Thus, given the historical importance of new and better quality products, the rising dominance of small firms is not good news for industrial competitiveness in sub Saharan Africa.

The results of the empirical analyses have important policy implications for industrial competitiveness in African countries. Obviously, countries should maintain and build upon competitive markets and stable macroeconomic regimes, which seem to have been achieved by most countries in the region. More attention should therefore be given to improving the predictability of the regulatory regime and creating a public-private partnership that boosts business confidence. Uncertainty not only undermines investment and innovation by incumbents, it also dictates entry with very small size, a development that is likely to weaken competitiveness. This study also suggests that investment by small firms could be enhanced by boosting these firms' access to formal sector credit. In transition economies, for instance, finance constituted the key constraint to growth for small firms compared to factors related to the business environment (Brown et al. 2005). Increasing the average skill level in the labour market through general education could undoubtedly improve firm-level efficiency. Nonetheless, a deliberate and focused effort to build the skills and expertise most needed by firms is herein very important. This goes in line with the need to expand and strengthen the science and technology infrastructure of African countries and link this infrastructure with a well developed and forward-looking industrial sector strategy. Such active intervention is justified by the specificity of capabilities required for certain products and the market failure that surrounds firm-level accumulation of technical capabilities. Recent studies based on disaggregated export data show that the fastest growing developing countries, India and China, are doing particularly well not just because they produce more of the products they used to produce, but because they allocate resources to build capabilities for new export items (not necessarily new to the world economy). In contrast, Agricultural Development-Led Industrialisation (ADLI) is the official industrialisation strategy of the current Ethiopian government – a strategy inspired by the traditional argument in which agriculture is called upon to provide the basic raw materials and demand for manufacturing. While this strategy may not be completely irrelevant given the country's current level of development and the potential advantages that may accrue from inter-sectoral linkages, the strategy seems oblivious to the more dynamic dimensions of competitiveness that derive from accumulation of technological capabilities and investment in new and better quality products. This analyses also suggests that government and donor programmes to support micro-enterprises in Africa, such as micro-finance, are unlikely to put the region's industrial sector on a path to long-term competitiveness. Why such interventions are unlikely to succeed has to do with the lumpiness of capital adjustment, which requires relatively large financial injections and also because of the crucial interdependence between firm size and building technological capabilities. While an active industrial policy that addresses the investment and innovation needs of firms is the way forward for industrial competitiveness in Africa, identifying the crucial elements of such policies requires rich information that can be generated only through a sound public-private partnership, which at the moment is in a fragile state in most African countries.

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