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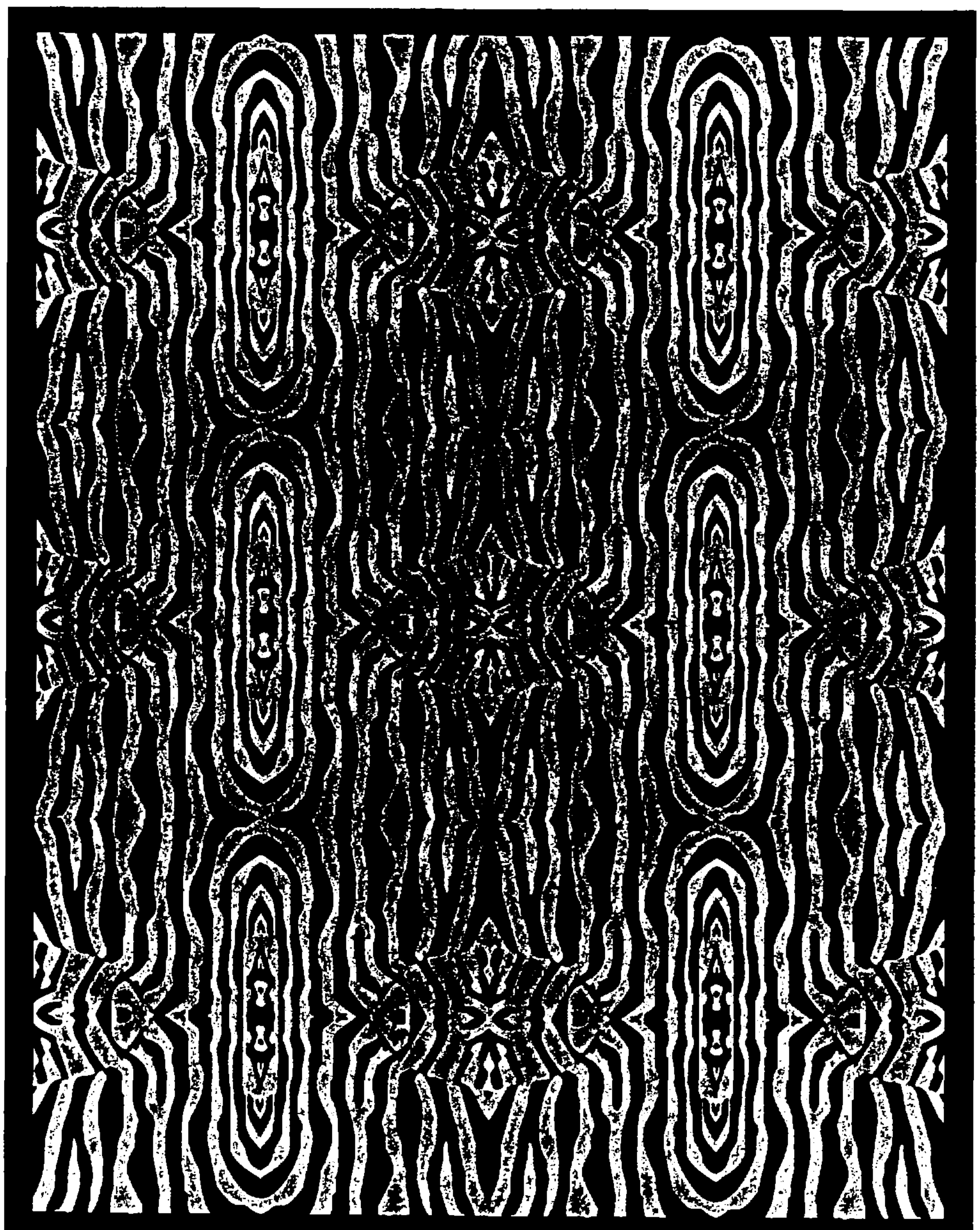
Technological Capabilities and Learning in African Enterprises

Tyler Biggs, Manju Shah, and Pradeep Srivastava



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Technological Capabilities and Learning in African Enterprises

Tyler Biggs
Manju Shah
and Pradeep Srivastava

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FOREWORD

One of the lessons emerging from structural adjustment efforts in Africa is that macroeconomic reform is necessary, but not sufficient to induce private sector growth. There are supply-side constraints that inhibit the growth of exiting firms and impede the entry of new ones. A major activity of the Africa Technical Department is the Regional Program on Enterprise Development (RPED), a research program designed to investigate these constraints and to offer suggestions for operational policies and support services to address them.

The RPED is engaged in two activities. The first is to collect survey data from a panel of large and small manufacturing firms in each of the following countries: Burundi, Cameroon, Côte d'Ivoire, Ghana, Kenya, Tanzania, Zambia and Zimbabwe. These interviews are conducted each year for three years and focus on four manufacturing sectors: textiles and garments, food processing, wood working and metal working. Discussions with entrepreneurs seek general information on the firm and on issues relating to technology, labor, financial markets, conflict resolution, infrastructure, regulation and the use of business support services. The second component of the program is a series of case studies on selected aspects of the research agenda: finance, business strategy and technological capability. These case studies are selected from a stratified sub-sample of the panel firms and are conducted to complement quantitative information gathered in the broader survey exercise. *Technological Capabilities and Learning in African Enterprises* is a study in the technological capability series.

One of the first systematic attempts to assess technological capabilities in Africa, the study is a synthesis and comparison of the levels of technological capability and learning mechanisms in three representative countries, Ghana, Kenya and Zimbabwe, all of which are undergoing extensive structural reform programs. As a group, the countries span the diversity of per capita incomes and industrial development patterns of the Africa Region. By opening up what usually is a sealed and unexamined "black box" labeled Technology, the study analyzes the separate roles and effects of the numerous components contained in that black box that together make up the technological capability of the enterprise.

Another distinctive aspect of the study is the use of stochastic frontier methods to estimate technical efficiency in the four sectors across the three countries. This marks the first such attempt at analyzing firm level inefficiency across Sub-Saharan African economies. Analysis of sources of technical inefficiency in the study shows that technological capabilities can be important determinants of efficiency at the firm, sector and country levels.

The study documents major gaps in each of the components of technological capability in these three African countries. Attempts at technological upgrading are in evidence in all the countries. However, technological capabilities, as expected, lag those of other low-income regions of the world. An examination of the channels through which firms traditionally "learn" shows that these channels are underdeveloped, incomplete and, in many cases, missing in the three countries, although there are some cross-country differences. The paper concludes with recommendations for how these learning mechanisms can be built up and identifies a critical role for the World Bank and other international agencies in the process.

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Abstract

This study is one of the first systematic attempts to assess technological capabilities of African manufacturing firms, to estimate their technical efficiency levels and to analyze the significance of technological capabilities in determining firm-level technical efficiency. Technological capabilities are broadly defined as the skills and knowledge needed to set up and efficiently operate modern industry. Using firm level data in Ghana, Kenya and Zimbabwe, the study evaluates components of investment capabilities, production capabilities and learning capabilities. Four industries provide the focus in each country: textiles and garments, wood working, metal working and food processing. It is shown that there are important cross-country differences in technological capabilities of firms, as well as across the four sectors of manufacturing activity. At the same time, although significant private efforts are being made by entrepreneurs in each country to upgrade their technological capabilities, the study finds that overall technological capabilities are low in these economies relative to the rest of the world. Econometric analysis using stochastic frontier methods is then undertaken to estimate levels of technical efficiency in the four sectors across the three countries. The estimation of technical efficiency is a distinguishing aspect of the study, marking the first such comprehensive attempt across Sub-Saharan economies. Analysis of technical efficiency shows that technological capabilities are significant determinants of efficiency at the firm, sector and country levels. The study also shows that the traditional learning and linkage mechanisms by which firms enhance their technological competence are weak and, many times, missing in African countries. Recommendations are offered for how development agencies can assist in building up these learning mechanisms, both in their private and collective forms.

Acknowledgments

This study, one of the Regional Program on Enterprise Development's (RPED) technology case studies, was sponsored by the Africa Technical Department, Private Sector Development and Economics Division, and a group of bilateral donors: The Belgian Administration for Development Cooperation, Canadian International Development Agency, Danish International Development Agency, Finnish International Development Agency, French Ministry of Cooperation, French Ministry of Foreign Affairs, Italian Ministry of Foreign Affairs, Netherlands Ministry of Foreign Affairs, Norwegian Agency for Development Cooperation, Swiss Development Cooperation, Swedish International Enterprise Development Cooperation and the Overseas Development Administration of the United Kingdom.

We would like to thank the following people who conducted the field work and analysis upon which the individual country case studies in Part II of this report were based. For Zimbabwe, this work was conducted by a team of RPED consultants Simón Teitel and Francisco Thoumi, and their collaborators at the University of Zimbabwe, Takawira Mumvuma and Moses Tekere. In Kenya, the team again included Mr. Teitel, Ricado Soifer (another RPED consultant) and their collaborators at the University of Nairobi, Gerrishion Ikiara and Wafula S. Masai. For Ghana, the team was composed of Sanjaya Lall, Giorgio Barba Navaretti, Simón Teitel and Ganeshan Wignaraja, along with Seth Adoo and K.A. Nuhu of the Ghanaian Ministry of Industry.

Preparation of the paper benefited from comments and editorial suggestions on earlier versions by Howard Pack and William Steel. Alfred Robinson provided extensive desktop publishing support.

Executive Summary

The supply response of the industrial sector to structural adjustment programs has been more sluggish than expected in Africa. This is causing concern in African governments as well as in the development community at large, and is stimulating an examination of factors beyond price distortions that may underlie the inadequate rates of growth. In addition to issues such as policy uncertainty and financial constraints, a critical area of concern in this context is the problem of technological capability. For firms to respond effectively to changes in incentives and to grow over time, entrepreneurs and workers must have the requisite technological capabilities — the skills and information required to establish and operate modern machinery, and the learning ability to upgrade these skills when needed.

Technological capabilities are also at the center of the new theories of economic growth which focus on technology and human capital as engines of growth. Recent developments in this literature suggest that long-run economic growth, as seen in East Asia most recently, reflects sustained increases in firm productivity stemming from continuous accumulation of technological capabilities. In this view, therefore, a liberal economic setting and policies to increase technological capabilities are the two blades of the scissors necessary to achieve increases in productivity and economic growth; either without the other is likely to be considerably less effective.

This paper reports on one of the first systematic attempts to assess technological capabilities and firm productivity in Africa. Despite their crucial importance, not much is known about technological capabilities and the resultant firm productivity the in African manufacturing sector. The study utilizes primary data from two surveys of manufacturing firms in each of three representative countries, Ghana, Kenya and Zimbabwe, all countries currently undergoing extensive structural reforms. As a group, these countries span the diversity of per capita incomes and industrial development patterns of the Africa region. The study undertakes a comprehensive analysis of technological capabilities and manufacturing productivity in these countries, focusing on a number of broad issues related to the patterns and determinants of manufacturing productivity, the levels of endowment of technological capabilities, the specific nature of technological efforts being undertaken by manufacturing firms, and the constraints they face in enhancing such endeavors. The objective of the investigation is to gain better understanding of the technological problems facing African enterprises, large and small, and to help the World Bank and other development agencies design more effective assistance programs to accelerate the supply response to policy reforms.

Technological capabilities cover a wide spectrum of technical efforts undertaken by firms. Consequently, to make their analysis manageable, technological capabilities are categorized in the study into three functional groups: investment and investment capabilities, production capabilities, and learning mechanisms. The first set of capabilities refers to the skills and information needed to identify feasible projects, locate and purchase suitable (embodied and disembodied) technologies, design and engineer the plant, and manage the construction, commission and start-up. The skills and knowledge needed for the subsequent operation and improvement of the plant are defined as production capabilities. Lastly, the learning mechanisms available to firms determine the extent to which they can augment their endowments of production and investment capabilities over time. This categorization is discussed in detail in Chapter 2 which also provides a conceptual framework linking technological capabilities, technical productivity and firm growth.

Manufacturing Productivity in Africa: Patterns and Determinants

The analysis of manufacturing productivity in the three Sub-Saharan economies (in Chapter 3) yields a number of important findings. Firstly, it is seen that African manufacturing displays structural relationships similar to those found in other developing regions. For example, comparisons with three Asian economies clearly indicate that in both Asian and African manufacturing sectors, smaller firms are not necessarily more labor intensive than large firms. In addition, the African firms display the same relationships between factor intensities and partial factor productivities as are seen in the Asian countries.

Secondly, there is considerable heterogeneity in the technical efficiency of firms across the three African countries. Firms in Zimbabwe are the most efficient on average in each sector while firms in Kenya are more efficient than their Ghanaian counterparts in at least two of the four sectors; Ghanaian firms, therefore, display the lowest levels of average technical efficiency. In contrast, variations in average technical efficiency across sectors are relatively insignificant in all three countries. With the exception of firms in the food processing sector, which display fairly little dispersion in estimated efficiency, the remaining three sectors appear broadly comparable in terms of total factor productivity.

Thirdly, patterns of inter-firm productivity differentials across firm sizes indicate that neither small nor very large firms are relatively the most efficient. Amongst firms with at least 20 employees, our results show that firm efficiency increases with firm size up to a point before declining for the largest sized firms. Firms with 100-199 workers are the most efficient in textiles and garment sector while in the other two sectors the most efficient firms on average are those with 50-99 employees. Thus, medium sized firms tend to be the most efficient in the sample. Firms in the food processing sector, however, do not display a strong relationship between firm efficiency and firm size.

Although ideally one would like to compare TFP in African firms relative to some international best-practice frontier, direct comparisons with other countries are not feasible due to lack of appropriate data. However, more indirect comparisons suggest that African firms on average have relatively lower levels of total factor productivity. For example, studies of efficiency specifically in the textile and garment sector in other countries yield indices of average technical efficiency much higher than that estimated for this sector within the three African economies. Furthermore, the results estimated here indicate that most firms surveyed in the study, except to some extent those operating in the food processing sector, are poor performers even in comparison to best-practices defined relative to firms within only these three African countries. If the reference best-practice frontier included more industrialized countries, the relative technical efficiency of African firms would appear even lower

The analysis of sources of inefficiency in the sampled firms yields additional important findings. In particular, the results show that *all* learning mechanisms that firms can use to change their endowments of production and investment capabilities have a large impact on enhancing productivity. On-the-job training of workers, both inside and outside the firm, has relatively the largest impact on value added by firms; specifically, an increase of 1 percent in the number of workers trained could increase the value added of the sampled firms by 60 percent. Similarly, informational links established by foreign direct investment contribute to an increase in value added by 30 percent, an impact comparable to that obtained by technology transfer through technical assistance contracts or licensing arrangements. Interestingly, the results also show that access to working capital financing is another critical determinant of firm efficiency. For the sample of firms as a whole, access to such financing increased value added by 37 percent. At the same time, the contribution to firm productivity of access to longer term bank loans is insignificant. This finding has implications for targeted credit policies which often place an exclusive emphasis on bank loans to finance fixed-asset acquisition.

A similar picture emerges when we consider only the very small firms and microenterprises and analyze determinants of firm productivity. Again training of workers is the most important contributor to higher value added by firms while access to working capital finance has an impact coefficient of 40 percent. In addition, previous experience of the entrepreneur and age of the firm, both of which contribute to human capital in the firm, are also positively associated with value added. The results also show that even within the very small firms, firms that are in the formal sector in the sense of being registered entities have substantially higher levels of value added than the small informal firms.

Endowments of Technological Capabilities in Firms

Given the importance of technological capabilities, and particularly of learning mechanisms, in determining manufacturing productivity, country case studies (Chapters 5-7) are utilized to provide additional details on the nature of technological effort undertaken in firms in the three countries studied. An important advantage of the case studies is that they allow greater qualitative details (e.g., whether or not plants display a good layout) about production and investment capabilities which otherwise cannot be captured fully in the large-scale survey used for the full sample of firms. A synthesis and cross-country comparison of the major findings in the case studies is provided in Chapter 4 of the study. The detailed "snapshot" of endowments of firm technological capabilities reveals levels that are significantly lower than international standards.

Thus, findings from the case studies indicate that inter-country variability in investment capabilities *within a given industry* is determined largely by heterogeneity in firm size and ownership. Multinational and local expatriate-run firms in each country generally have the necessary skills in-house or via the parent company to acquire technology and execute investment projects efficiently. A few indigenous large enterprises have sufficient capabilities to invest in complex industries. Most of the remainder, however, need to upgrade their skills to move out of simple, labor-intensive activities. Zimbabwe, by all indicators, exhibits the highest level of national capability, followed by Kenya. Where both Kenya and Zimbabwe exhibit shortcomings is in the uneven spread of their more advanced investment capabilities. Outside the white community in Zimbabwe and the Asian community in Kenya, black African entrepreneurs are less likely to possess the required investment capabilities to be able to enter complex production activities.

Similarly, production capabilities show equally deficient levels across all three countries but with considerable cross-country variation. Again, firms in Zimbabwe display the highest levels of skills in terms of better designed plants, ability to maintain and repair equipment to keep it running in an efficient manner, use of quality control mechanisms, and some use of industrial engineering techniques. Ghanaian firms, in contrast, show significantly lower levels of production capabilities relative to the ones in Zimbabwe and, to some extent, in Kenya. In comparison to countries outside Sub-Saharan Africa, however, all three countries show low firm endowment of production capabilities.

Finally, the country case studies also undertake a detailed look at learning mechanisms available to firms in the three countries. Learning mechanisms constitute the most important category of technological capabilities since they enable firms to augment their endowments of the other two types of capabilities. Two types of learning mechanisms are distinguished: private and collective. Private learning mechanisms may be internal to the firm, such as in-house training and R&D, or external, involving relationships with buyers and suppliers, interactions with other firms through subcontracting, industry networks, and hiring local or foreign consultants. Collective mechanisms, on the other hand, consist of technical support services provided by NGOs, business associations, the government or donors.

The comprehensive evaluation of learning mechanisms reveals, on the whole, a somewhat bleak picture. With the exception of multinational companies and a few large exporters, most firms are technologically isolated from the rest of the world. As a consequence, connections with international private learning sources, such as foreign buyers and suppliers, are weak or non-existent. Zimbabwe and Kenya are somewhat better off in this respect because they have relatively large, local expatriate business communities who have the advantage of being embedded in extended social and business networks, via family and other connections, which transcend national boundaries. Zimbabwe also benefits from its proximity to South Africa. The diffusion of benefits from these international connections, however, are constrained in Zimbabwe and Kenya by limited business interactions between the expatriate and indigenous communities.

Most firms operate in an information-poor environment: (i) there are very few vertical and horizontal linkages between firms because large enterprises tend to be vertically integrated and there is very little subcontracting; (ii) direct foreign investment is limited, reducing the ability to "learn-by-copying" and the ability to "benchmark" the firm's operations against internationally competitive firms in the same business; (iii) training opportunities and specialized consultancy services are weak or non-existent locally, and expensive if imported; and (iv) information sources on technical and business matters are poor

Collective support services to assist and facilitate enterprise technical learning are often poorly delivered, when they exist at all. Business associations are also weak and deliver very few services, if any. NGOs and international development agencies provide some useful services, but coverage is limited and the support services are aimed at only a few areas, like finance.

With such poor external learning sources available to them, African firms are forced to rely almost exclusively on internal learning efforts to build their technical capabilities. By itself, this fact is not particularly problematical: internal efforts have been identified as the most important source of technological capabilities amongst successful small-scale exporters in Asia and Latin America. The problem in Africa is that internal technical efforts of firms, with the exception of a few large multinationals, appear to be less than what is needed, limited in scope and sporadic rather than continuous. For example, internal efforts at R&D are both quantitatively and qualitatively minuscule in international terms. Similarly, internal training of workers is widely prevalent among firms, with patterns of incidence remarkably similar to those found in other countries, but with levels that are much lower than international averages. Thus, without the availability of adequate external learning channels to increase the inflow of new know-how, internal learning activities can not go very far in upgrading skills towards internationally comparable levels.

Technology Policy for Africa

Given the very low levels of technological capabilities endowments and the resulting relative technical inefficiency of African manufacturing firms, a comprehensive technology policy for Africa has to, by necessity, encompass a broad framework, not all of whose elements can be done justice to within the present study. In particular, we focus on policies directly related to firms, and the private and collective learning mechanisms that help firms accumulate technological capabilities over time. Other policy issues are dealt with relatively briefly.

Conceptually, manufacturing productivity can be thought of as being determined by four types of factors: (i) those that affect efficiency indirectly by altering the functioning of the national economy; (ii) those that directly affect the efficiency of an industry as a whole; (iii) those that influence the technical capability and efficiency of the individual enterprise; and (iv) those whose main impact is on the task-level efficiency of individual workers. Obviously, such a decomposition is basically heuristic in that it indicates only proximate, not the ultimate, sources of manufacturing efficiency. For example, the immediate locus of low task-level efficiency may be inadequate training by the enterprise. However, the firm's own cost of training will be influenced by the effectiveness of the national education system, as well as the availability of industry-specific training courses. Additionally, the adverse incentive effect of excessive trade protection may manifest itself at the industry and firm levels in the form of inordinate product differentiation and inadequate technical know-how.

Yet, in spite of the complexity of the causal links, the decomposition is useful for identifying different levels of policy concern.

National-level Policies

Nationwide policies in the form of macroeconomic policies, financial system development, infrastructure, and national education attainment have important impact on the efficiency of *all* firms. It is important to emphasize, therefore, the need for continued structural adjustment of the economies in terms of macroeconomic reforms and elimination of gross distortions in prices and incentive structures. In addition, however, a number of issues specifically in the context of technological productivity deserve attention. In the near term, efforts should be devoted to raising the efficiency of existing firms by alleviating some of the key constraints on capacity utilization, which has a significant impact on firm productivity in all three countries as shown by the empirical analysis.

In the longer term, two areas of policy concern are human capital development and trade policy. The stock of human capital is a priority issue for two reasons. Firstly, dynamic comparative advantage of industries is very sensitive to small changes in the scarcest factors of production. For example, assuming correct choice of technology, the cotton textiles industry can grow dramatically in these countries since it is a process based, labor intensive activity with limited linkages to other manufacturing sectors. Yet, the emergence of a competitively viable cotton textiles and garments industry can be severely constrained by the absence of 50 or 60 key technicians. Secondly, the stock of human capital in the form of general levels of educational attainment can also constrain market responses to skill shortages. With high overall educational attainment, small amounts of additional training can increase inter-sectoral mobility of labor in response to changing price incentives. This flexibility is severely restricted with the low education and skill levels of labor in the African economies. Regarding trade policy, there is no *a priori* reason why Africa should not benefit from some form of infant industry protection to promote learning in domestic firms, as has been evident in case of most successful developers in this century. However, given previous experiences with such policies, critical issues related to appropriate administration, monitoring, enforcement and, most importantly, time-bound elimination of these trade policies need to be carefully addressed.

Industry-level Policies

The principal objectives of industrywide policies in Africa should be to reduce the inter-firm variance in efficiency observed in given industries, and to raise the average productivity of the best local firms closer to international best practice. To some extent, the heightened competitive pressure induced by policy reforms in most countries is causing firms to reduce sloth and slack and move towards best practice. There are, however, some problems which might be lessened by proactive, industry-level policies.

For example, firms will tend to underinvest in general types of training because worker mobility may prevent them from reaping the full benefits of such investments. For this reason, basic types of training are best organized on an industrywide basis, where firms are induced to cooperate in the effort via membership in industry associations or by government. In such cases, all firms would pay some contribution to basic industry-specific training based on, say, a profit tax or some other scheme. To be effective, it is best that such training schemes be run with a good deal of firm involvement. There are currently vocational training programs in many African countries, financed by "training levies", which are operated by government at much too great a distance from real businesses. Genuine, industry-run programs or those with heavy business-government cooperation tend to be most successful, as the experience of East Asia indicates.

A second area where industry-wide policies may be called for arises where the source of inefficiency arises from insufficient product specialization within firms. In many African industries, firms produce a diverse array of products, foregoing the benefits of specialization. For example, absence of horizontal specialization leads to significant productivity losses in integrated textile mills engaged in the assorted activities of spinning, weaving and dying. The problem is how to achieve greater specialization if market forces, via liberalization, do not induce it spontaneously. The mechanisms that have most often been employed to obtain benefits from greater specialization are industry-wide cooperative agreements.

Firm-level Policies

Firm level policies are perhaps the most critical element of any technology policy, since firms are the most important actors in accumulating technological capabilities through developing, establishing and operating specific production systems. The central objective of firm-level technology policy should be to encourage and support this learning process in existing firms and to enhance incentives for innovation and imitation. Furthermore, such policy should embody the most fundamental aspect of technology accumulation, namely, the role of *individuals* in transmission and diffusion of technology. A large part of technology, both new production processes and products, involves uncodified knowledge: rules of thumb acquired only with experience and via sustained interaction with the people and institutions embodying this know-how. Both within countries and transnationally, virtually all studies of technology transfer find that the diffusion of technology results, in the main, from movements or interactions of individuals from firm to firm and from country to country. There appears to be *no* evidence that the transfer of technological know-how can be achieved effectively by other modes independently, such as via technology licenses or, for that matter, blueprints sent over the Internet unaccompanied by sustained individual interaction.

The leading source of technical learning in firms in all countries is via private channels — either internally from technical efforts within the firms themselves; or externally, from business interactions with buyers and suppliers, from interactions with other firms in the same industry, from hiring consultants and other technical experts, and so on. Internal technical efforts, as documented by the study, are occurring in all three African countries in the form of on-the-job training of workers, R&D and development and use of technical documentation within the firms. African firms appear quite similar to firms in other countries with respect to the patterns and determinants of internal technical efforts. For example, it is shown in the study that, as in other countries, large firms train more than small firms, that foreign-owned firms train more than domestic firms, exporters train more than non-exporters, and that managerial and skilled workers receive more training than unskilled workers. However, where African firms differ from their Asian and Latin American counterparts is in the overall incidence and quality of internal technical efforts.

Furthermore, the internal technical efforts of firms will not amount to much if the environment in which the firm operates is not supporting these efforts with new inflows of know-how, new market connections and access to individuals with technical expertise. These external sources of learning, both private as well as collectively provided, are extremely weak or missing altogether in the three African countries. Thus, as noted above, most firms are technologically isolated from the rest of the world. Moreover, domestic firms operate in an information-poor environment. There are a small number of firms in each modern industrial sector, which means that firms cannot rely on inter-firm flows of information or employees to acquire new products and production knowledge, as in the more industrialized countries.

Private Learning Mechanisms

These private external learning mechanisms, as shown in the study, add as much as 30 percent to the value added of firms. Consequently, enhancing the levels of such mechanisms is an important policy objective. Measures here span a wide range of issues, but might include: (i) Reducing the problems and costs to firms in hiring experienced expatriate personnel. This would include things like making expatriate salaries tax free and easily repatriable; (ii) Making the environment better for foreign direct investment in key labor-intensive industries and encouraging vertical and horizontal links with local companies; (iii) Finding ways to lower transactions costs of sub-contracting. Inter-firm linkages through transactions in goods or services, both vertically and horizontally across firms, are minuscule in Sub-Saharan African economies. An important reason for this lies in high costs of enforcing private business contracts. Thus, finding inexpensive ways to enhance contract enforcement, either through private or public mechanisms, can reduce the transaction costs and risks or subcontracting considerably, thus improving substantially inter-firm flows of technological know-how.

Given the evident limitations of existing private learning mechanisms in Africa today, proactive intervention at the firm level to accelerate technological accumulation deserves high priority. Evidence from other developing regions of the world indicates that there are large benefits to be derived from collective external technological support to firms, if it is implemented properly. In addition, private learning mechanisms appear to be most readily available to larger firms with some foreign ownership or educated entrepreneurs who can take advantage of private network linkages.

Collective Learning Mechanisms

An exclusive reliance on private learning mechanisms may reduce the participation of small firms, which in Zimbabwe and Kenya are primarily owned by black Africans, in the technological upgrading process. Hence, there are reasons why policymakers should also focus on collective learning mechanisms as part of an overall firm level strategy. Collective technical support programs generally take two basic forms: "broad-based" or "high-intensity". *Broad-based programs* may include provision of industry-specific courses on specialized topics, facilitating the use of technical consultants by providing financial assistance, making technical information available, and promoting information sharing among firms. The most highly desired broad based services according to the African firms surveyed by this study were specialized technical courses and technical assistance for productivity improvement. A first priority for broad-based collective support programs, therefore, should be to deliver effective service in these areas. These services will be particularly important for small, black-owned firms.

Secondly, given the tacit nature of technology dissemination and the current low technical capability endowments in Africa, the necessary changes in production engineering to raise productivity are not likely to be successfully implanted on a one-shot, short-term or sporadic basis typical of technical consulting or short courses. Ways will have to be found to provide broad-based support on a more sustained basis in Africa.

Thirdly, there is a strong need for institutional capacity building in the provision of broad-based technical support services. Given that these services are best provided on a decentralized basis so as to be able to be close to clients, and that there are few decentralized providers in Africa, a central objective of policy must be to build up the necessary institutional infrastructure. Key institutions, like industry associations and independent NGOs need to be strengthened to deliver broad-based technical support. Centralized providers, which currently deliver some of these support services in Africa, could also be encouraged to move closer to clients to increase the effectiveness of existing programs.

Fourth, collective support efforts need to focus on creating and maintaining foreign market linkages in Africa to foster more learning-by-doing. For example, broad-based programs are needed to finance trips for African producers to foreign markets. Producers might receive assistance to go to trade shows and visit buyers and suppliers. Foreign buyers might also receive support to visit African producers. The support for individual-based knowledge transmission can be supplemented by publications, seminars and exhibitions by the technical support agencies.

Lastly, provision of quality control testing and inspection services should be part of any broad-based collective support effort. These services are listed as highly desired by the surveyed firms, reflecting the perceived need in these countries to meet higher quality standards brought on by more extreme competition under current policy reform programs.

Regarding collective mechanisms for *high-intensity technical support*, their objective is to directly meet specific technical needs of firms which cannot be met via any other types of mechanisms. Demand for this type of direct support comes from firms operating in relatively high levels of technological complexity. Examples of high-intensity support include direct technical assistance from government technology institutions in the form of productivity improvement or joint technology development programs. Ghana, Kenya and Zimbabwe all have government technology institutions of one kind or another. However, few firms report using these high-intensity services and fewer still have anything good to say about them. Given the record of centralized provision of services in Africa and the pervasive organizational weaknesses of public institutions — in terms of human capital, commitment and funding — the potential for delivering high intensity technical support is severely limited. The government's role in this area, therefore, should be to support private-to-private technology provision. Assistance for training and technical consultants by public agencies to support delivery of these services by non-government providers on a decentralized basis would also be beneficial.

Task-level Policies

The task-level efficiency of African workers is low by international standards. Two factors which can make a significant difference in raising worker productivity are more experienced management and systematic worker training. In process-oriented industries, such as textiles and garments, substantial previous worker experience is not a prerequisite for success. Formal on-the-job training in firms for relatively short periods can be quite successful in raising worker productivity to internationally competitive levels, given one starts with literate and numerate workers. A priority for policy aimed at increasing worker task-level efficiency should, hence, be to support enterprise training.

A second area that policy must address at the task level is the shortage of skilled managers and technicians. For workers to be productive, they need adequate supervision, efficient plant layouts and effective incentive schemes. Firm training also requires skilled and experienced personnel to run courses and to actively be involved in on-the-job learning. Given the shortage of skilled personnel documented by the study, one of the best ways in the short run to relieve such critical bottlenecks is also to facilitate the hiring of experienced expatriates.

Lastly, as African countries become more outward-oriented and workers begin producing more tradable goods, task-level efficiencies of workers and managers should rise rapidly. Many studies show that worker productivity, driven by learning-by-doing, rises faster in the production of tradable goods than in the production of non-tradable goods. Hence, the rate of increase in task-level efficiencies will, inter alia, be determined by the speed and extent of the shift toward openness of the economy. Historically, such increases in human capital on the job have been at the center of rapid industrial growth rates, particularly in the newly industrializing Asian countries. Assisting African producers to overcome the transaction costs of entering world markets is one of the keys to unlocking this powerful engine of growth.

Part I:
Technological Capabilities and Technical Efficiency

1. Introduction

The supply response of the industrial sector to structural adjustment programs has been more sluggish than expected in Africa. This is causing concern in African governments as well as in the larger development community. Expectations about the effects of policy reform were largely based on the neoclassical assumption that supply elasticities are relatively high and, therefore, that improving the structure of price incentives and privatizing public enterprises would elicit a speedy and sizable response in private-sector investment and output. The fact that supply turned out to be more inelastic than expected has stimulated an examination of factors other than price distortions that may be constraining growth.

Prices matter, that is clear. But other factors are also important in conditioning the speed and magnitude of response to policy reform programs. Investment demand can be constrained by policy uncertainty, for example. Any uncertainty about government's commitment to the reform effort can cause investors to wait. On the supply side, financial intermediaries may have problems gathering information on the creditworthiness of firms in the post-reform environment, causing them to reduce overall availability of credit. In addition, there is the crucial problem of technological capability, which is the subject of this study.

In order for firms to respond effectively to the post-reform structure of incentives, entrepreneurs and workers must have the requisite technical capabilities — the skills and information to establish and operate modern machinery and the learning ability to upgrade these skills over time — to do so. Shifting industrial supply curves requires intersectoral reallocation of resources toward lower domestic resource cost activities, as well as moves within firms toward best practice production technologies. Both of these responses require managerial and worker technical effort and skill. As Pack (1993) argues, "a liberal economic setting and a policy to increase technological capabilities are two blades of the scissors necessary to achieve increases in productivity. Either without the other is likely to be considerably less effective."

Technological capabilities are at the center of the new theories of economic growth which focus on technology and human capital as engines of growth (Romer 1986; Stokey 1988; Young 1991). Recent developments in this literature suggest that long-run economic growth, as seen in East Asia most recently, reflects sustained increases in firm productivity stemming from continuous accumulation of technological capabilities. One of the central lessons that emerges from this work, as well as from empirical studies, is the relatively minor role of physical capital accumulation. Accumulation of human capital in the form of technological capability on the job appears to be much more important to sustained development success (Lucas 1993).

The importance of technological capability and learning is generally better understood in industrialized countries, where technological effort, generally in the form of developing new process or product know-how, is taken to be a vital basis of market success. The significance of technological effort is generally less well appreciated in developing countries, however. Because almost all technologies are imported from developed countries, and their application is already known and understood, it is widely believed that African firms need to invest little in their own technological effort. They are thought to be passive recipients of technology, choosing from a "shelf" of available techniques those appropriate to their factor endowments. Having made this choice, the basic assumption is that they can always use the technology efficiently.

Experience in Africa and other parts of the developing world indicates that the process by which private enterprises upgrade their production technologies is far more complex and demanding. The selection, assimilation and effective deployment of technologies is not a passive process. The search for suitable technologies in imperfect markets for technical knowledge is difficult. The use of imported technologies requires firms to seek new information, skills, material inputs, investment resources and management organizations, the markets for which are riddled with imperfections in Africa. Some firms are in a better position to engage in these efforts than others and the degree of market imperfections varies by country.

Africa appears to suffer from two significant technology gaps. The first is a large, and in many cases widening, gap between the technological capabilities employed by African firms and those employed by firms in other parts of the world. Part of this gap in average capabilities appears to be due to a large variance in domestic capabilities which exists among firms within manufacturing industries. Africa exhibits much more inter-firm technological heterogeneity than other developing regions. The second is a gap in the "learning" environment in Africa compared to other developing regions. The infrastructure for technical learning in Africa appears weak, in that many key learning mechanisms which provide the basis for technological upgrading in other developing countries are absent. Some of the reasons for these gaps can be traced to Africa's development history, to the current business environment and to the process of technological development itself.

Africa's post-independence industrialization strategy focused on creating physical capacity. Import substitution policies promoted local and foreign investment by way of highly protected markets. Public investment, financed by taxation of agriculture and foreign borrowing, concentrated on setting up heavy industry. The capacity that was created was often not well articulated to local demand and supply conditions, and much of it could not be sustained. Many industries remained isolated from world markets and new technology, with high costs relative to best practice operations elsewhere. Protected markets did stimulate investment and production, but not much innovative activity or learning to raise productivity. Africa, as a consequence, has not only had problems catching up with the rest of the world, but actually has begun to fall further behind. The increasing gap has been on two fronts — plant and machinery, and management and labor skills to master new technologies. Particularly in this second area, the lesson to be learned from the successful East Asian "tigers" is that systematically building up capabilities step-by-step to operate and adapt new technologies pays off.

Domestically, the observed technology gap between firms seems to have several causes. First, demand factors influence the choice of technique in production. Inequalities in the distribution of income tend to bifurcate markets into high and low quality segments. This market segmentation is reinforced by local tastes and preferences and high transport costs. The influence of demand factors is to foster dualism in terms of the technologies in use. Firms producing in the lower quality segment of the market have little incentive to devote technological effort to upgrading equipment and worker skills, and to improving product quality because the market does not reward higher qualities. Only if the firm has the resources and skills to make the jump to the high-end market or to exports will technological efforts to upgrade quality really pay off.

Second, because of the nature of factor market imperfections in Africa, different firms face different factor prices. Small and medium enterprises have tremendous difficulty getting access to financial markets and pay a heavy premium when they do. In labor markets, smaller enterprises generally pay lower wages. Such observed differences in relative factor prices cause firms to adopt different production techniques and to expend technological effort in different directions. As a result, within any industry one observes large inter-firm productivity differentials.

Lastly, differences in firm-specific initial endowments of technological capability and entrepreneurial ability facilitate selection, assimilation and effective deployment of technologies by particular firms. As we noted above, certain capabilities are required to use a given technology efficiently. Firms which possess these capabilities will be able to adopt new techniques and get ahead. Over time, these firms "learn how to learn" more effectively than other enterprises and they may stay ahead or widen the technology gap. Capabilities which facilitate adoption and efficient use of technologies, often cannot be found or are not readily available on the market. Markets for knowledge and other such inputs are also characterized by imperfections. As a consequence, the process of technology development itself (the "learning" or capacity-building process) inevitably creates technology gaps.

As African countries liberalize trade and expose their firms to the rigors of import and export competition, the hope is that these technology gaps will begin to close. Empirical observation to date, however, raises some questions about how this will take place and the speed of its occurrence. Do African firms currently have the technological capability to deal with such exposure? If not, are there ways to assist them in incorporating and deploying new techniques at a rapid enough pace to become internationally competitive? And, if formerly protected activities are basically inefficient and die out, will new dynamic manufacturing firms emerge in the new environment to take their place?

This paper reports on one of the first systematic attempts to assess technological capabilities in Africa. The study utilizes primary data from three representative countries generated from surveys of manufacturing enterprises in Ghana, Kenya and Zimbabwe, all countries currently undergoing extensive structural reform programs. As a group, the countries span the diversity of per capita incomes and industrial development patterns of the Africa Region. The objective of the investigation was to gain a better understanding of the specific technological problems of African enterprises, large and small, to help the World Bank and other development agencies design more effective assistance programs to accelerate supply response to policy reform programs and to foster long-run industrialization.

The organization of the study is as follows. The remaining two chapters in Part I provide a discussion of technological capabilities and technical efficiency. Chapter 2 presents a conceptual framework to classify different types of technological capabilities characterizing the technical efforts undertaken by manufacturing firms. In addition, the chapter also contains an analysis of the relationship between technological capabilities and firm productivity using the framework of neoclassical production theory. Chapter 3 provides a detailed empirical analysis of manufacturing productivity in Ghana, Kenya and Zimbabwe. This is a distinctive aspect of the present study, marking the first such comprehensive attempt at estimates of technical efficiency at firm, sector and national levels across these Sub-Saharan economies. Econometric analysis of sources of technical inefficiency is also presented in this chapter, with a focus on the extent to which different types of technological capabilities are important determinants of firm-level efficiency.

Much of the data utilized in Chapter 3 comes from a large-scale survey instrument administered to manufacturing firms in the three countries (characteristics of the survey data are presented country-by-country in each of the country case studies in Part II). However, many aspects of technological capabilities are not easily quantifiable and, therefore, not fully captured by such large-scale survey instrument. Given the importance of technological capabilities in affecting firm productivity and performance, a sub-sample of firms was chosen in each country for a detailed case-study survey. These surveys provide a much finer look into the nature of technological efforts being undertaken by the surveyed manufacturing firms. These detailed "snapshots" of the existing endowments of technological capabilities of firms are presented as separate country studies in Chapters 5, 6 and 7. Chapter 4, on the other hand, provides a synthesis and cross-country comparison of the major findings from the case studies. The country studies, which contain a considerable amount of qualitative and quantitative detail, follow a similar structure and are, by design, self contained. Consequently, it is possible for the reader to focus on any one of them and combine it with the cross-country synthesis and comparisons presented in Chapter 4.

Finally, Chapter 8 in the last part of the study draws together the main conclusions of the analysis, and discusses implications of the study for formulating a technology policy for Africa.

2. Technological Capabilities: Conceptual Framework and Measurement of Firm Productivity

The analytical approach employed in this study opens up what usually is an unexamined "black box" labeled "Technology". It unpacks and analyzes the separate roles and effects of the numerous elements contained in that black box that together constitute technological capability. These components include machinery and equipment but also human behavior, product design and production process, organizational systems and marketing skills. Some of these components are quantifiable while other are not. This chapter provides a detailed classification of the different types of technological capabilities characterizing the technical tasks undertaken within firms. The same framework is utilized in the empirical analysis of technological capabilities in manufacturing firms of Ghana, Kenya and Zimbabwe in Part II of the study. In addition, the relationship between technological capabilities and firm productivity is also analyzed in this chapter. Using a framework of neoclassical production theory, the chapter discusses how technological capabilities are critical in determining technical efficiency of manufacturing enterprises.

What Are "Technological Capabilities"?

Technology has been described as "the systematic application of scientific and other organized knowledge to practical tasks" (Galbraith, 1971, p. 31). *Technological Capabilities* are the information and skills — technical, managerial and institutional — that allow productive enterprises to utilize equipment and technology efficiently.[1] While there are some constants, such capabilities are in general sector and firm specific, a form of institutional knowledge that consists of the combined skills accumulated by its members over time. *Technological development* is the process of building up such capabilities.

The development of technological capabilities should not be thought of as the ability to undertake leading edge innovation, though innovative capabilities are an important element of technological capabilities. Technological capabilities comprise a much broader range of effort that every enterprise must itself undertake in order to absorb and build upon the knowledge that has to be utilized in production. This involves buying some skills and information from the market and providing others in-house, the choice depending on the technology, market conditions and firm strategies.

Consider, for example, the successful transfer of a new technology to a developing country. Acquiring equipment and operating instructions, patents, designs or blueprints does not ensure that the technology will be properly used. Elements of a technology embedded in a process or equipment are accompanied by additional "tacit" elements, which the recipient must learn, as well. Only when such learning and adaptation have taken place can the

[1] The language of "capabilities" (technological capabilities or firm capabilities) rather than the more standard textbook theoretical categories of production function and production sets is identified with the field of inquiry known as evolutionary economics (see Nelson and Winter (1982)). In this literature, the main task is to understand the processes of change in firm capabilities and their effects on performance.

technology be considered to be "mastered,"[2] that is, used at or near the "best practice" level of technical efficiency for which it was designed. Technological mastery is not an automatic or passive process. In particular, there must be adequate "receptors" of technology, who invariably are qualified technical personnel. If not available before the transfer occurs, they must be developed rapidly by on-the-job training and other means.[3]

Technological capability is more, however, than the simple sum of the education and training of a firm's employees. It includes the learning undergone by individuals in the course of working in the enterprise and the way in which the firm combines and motivates individuals to function as an organization.[4] To some extent any enterprise that tries to use a new technology acquires some capabilities as an automatic result of the production process. Such passive learning goes some way to developing the necessary capabilities. In simple industries, say the assembly of imported kits or garment manufacture for the domestic market, this may be all that is needed. The skills are easily learned on the job, and there are few linkages with suppliers that involve technical problems and complex exchanges of information. Product designs are provided by foreign suppliers of kits for assembly, or are easily adapted to local tastes in garments.

However, as the technology becomes more complicated or market demands more rigorous, such passive learning is inadequate. Even in garment manufacture, much effort is required to raise quality and productivity, improve layout, introduce new supervisory practices, before an efficient producer for the local market becomes a competitive exporter. For more complex industries, an enterprise must be prepared to sustain a longer and more demanding process to reach even static, best practice, levels established by producers in advanced countries.

Achieving a static level of competence is necessary but rarely sufficient to be competitive. It is generally necessary to *adapt the technology* in various ways, to a smaller size of plant or production batch (termed "downsizing"), different climate and raw materials, different product characteristics and different skill availabilities. Whatever the reason, successful adaptation of a technology or machine requires engineering and technical skills and effort, the nature of which depends on the technology in question. A benefit is that modifications of products, processes and equipment themselves create new knowledge, often leading to further improvements. This process of "minor" innovation can accumulate over time to significant improvements in productivity, sometimes larger than major single jumps in technology.[5] The nature of this learning process means that different firms can operate at quite different rates of technological development, and end up with different levels of

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[2] As seen below, mastery requires systematic training, searching for technical information, in-house engineering and experimentation. For a detailed analysis for the constituent elements of the "learning curve," see Adler and Clark (1991).

[3] Mody (1989) analyzes the strategy that firms can adopt to undertake learning and the determinants of rates of learning, focusing on inputs of skilled engineering manpower.

[4] On the significance of organizational factors in absorbing and innovating technologies, especially in the engineering industry, see Hoffman (1989). Enos (1992) has a perceptive analysis of the institutional needs of capability development.

[5] Rosenberg (1986). See also Arrow's classic work (1962) on the significance of learning by doing.

efficiency while using the same technologies. Note, too, that the learning process for complex technologies can be long and uncertain.[6]

The approach to capability development just described may be usefully contrasted to the usual textbook analysis of how firms absorb and use technology, wherein firms are assumed to operate with full knowledge of all possible technologies. In the context of industrializing countries, it follows then that the firms can use this knowledge to buy the right technology "off the shelf." The firms can, moreover, immediately use the imported technologies with the same degree of efficiency and at best practice levels. Where learning costs of introducing new technologies are admitted, the learning process is viewed as relatively low cost and simple, confined to "running in" a new plant until the benefits of learning-by-doing are automatically realized.[7] There is, thus, no theoretical reason in such a framework to expect the persistence of technical inefficiency. If such an inefficiency exists, it is *ex hypothesi* due to managerial slack or incompetence, and to government interventions that allow inefficient firms to continue in production.

Once the simplifying assumptions about technological absorption and development are dropped and market failures in the learning process admitted, the resulting picture is necessarily more complex. In particular, the need for interventions to help the learning process, and for sustaining lengthy periods of learning, or relearning in the case of existing firms that have to restructure and upgrade to face liberalization, has to be taken into account.

Functional Categorization of Technological Capabilities

Technological efforts directed at productive efficiency and enhanced performance are not a separate task in the care of a special department of an enterprise. These efforts can take place at almost any point in the manufacturing firm: shop-floor, quality control, process engineering, product design and testing, input procurement, formal R&D, and so on. They can also take a variety of forms. To make the analysis of technological capabilities empirically manageable, this section describes a simple functional categorization of the technological tasks facing a manufacturing firm. All manufacturing firms need to perform these tasks, but not necessarily all in-house. The tasks and the associated technological capabilities can be grouped into two broad categories: *investment capabilities* and *production capabilities*. An illustrative matrix depicting these is presented in Table 2.1 below. This set of technological functions will be used in Part II of the study to evaluate technological capabilities of manufacturing firms in Ghana, Kenya and Zimbabwe. The third, and perhaps the most critical, element constituting firms' technological capabilities is the set of *learning mechanisms* available to acquire new, or improve existing, investment and production capabilities. Each of these three elements, namely, production capabilities, investment capabilities and learning mechanisms is discussed below.

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[6] It has been found, for instance, that the best Korean firms have needed from 10 to 20 years to absorb complex capital goods technologies to the level of becoming internationally competitive. See Jacobsson (1993).

[7] Furthermore, firms acquire and use technologies atomistically with no linkages or externalities in generating skills and information.

Table 2.1
Illustrative Matrix of Technological Capabilities

Level of Complexity	*Investment*			*Production*	
	Pre investment	*Project execution*	*Process engineering*	*Product engineering*	*Industrial engineering*
Simple, Routine (experience based)	Pre-feasibility and feasibility studies, site selection, scheduling of investment	Civil construction, ancillary services, erection, commissioning	Debugging, balancing, quality control, preventive maintenance, assimilation of process technology	Assimilation of product design, minor adaptation to market needs	Work flow, scheduling, time-motion studies, inventory control
Adaptive Duplicative (search based)	Search for technology source, negotiation of contracts, bargaining suitable terms, information systems	Equipment procurement, detailed engineering, training and recruitment of skilled personnel	Equipment stretching, process adaptation and cost saving, licensing new technology	Product quality improvement, licensing and assimilating new imported product technology	Monitoring productivity, improve coordination
Innovative, Risky (Research Based)		Basic process design, equipment design and supply	In-house process innovation, basic research	In-house product innovation, basic research	

Source: Lall, S., G.B. Navaretti, S. Teitel and G. Wignaraja, 1994. *Technology and Enterprise Development: Ghana under Structural Adjustment.* London: Macmillan.

Investment Capabilities

Every application of technology begins with an investment. *Investment capabilities* are the skills and information needed to identify feasible investment projects, locate and purchase suitable (embodied and disembodied) technologies, design and engineer the plant, and manage the construction, commissioning and start-up. These functions are not always easy to perform. Many enterprises in developing countries find it difficult to decide on the best technology (or complex combinations of technologies) for their purposes. Technology markets may be fragmented, and it is often difficult for developing country firms to find the best suppliers and negotiate the most appropriate terms and prices. Furthermore, the difficulty of financing new technology from a hard currency supplier out of soft currency revenues means that frequent upgrading or replacement is not a realistic option. Sub-Saharan African manufacturers thus must be more prescient than their counterparts in OECD countries and select technology that is robust enough to compete on a world basis over many years.

Contracting investment functions out to international engineering firms can get around some of these problems. This approach may, however, raise the project's capital costs and result in the technology being provided as a turnkey operation in which the recipient does not participate and, as a consequence, finds it difficult to master, and subsequently to adapt or upgrade the technology. More generally, the development of investment capabilities in an industry or country, rather that just in an enterprise, can be of great help in setting up plants economically and, later, expanding and improving upon them. The experience of Japan and the Asian Newly-Industrialized Countries (NICs) shows that growth in the domestic ability to select technologies, negotiate favorable terms for its transfer and participate in the design and setting up of the plant can greatly reduce project costs and increase the subsequent capabilities for technology adaptation and improvement.[8]

Production Capabilities

Once a firm has acquired a technology of any sort, it must have adequate production capabilities to remain in business. *Production capabilities* are the skills and knowledge needed for the operation and improvement of a plant. As the table shows, these capabilities range from routine functions to intensive and innovative efforts to adapt and improve the technology. Their classification by degree of complexity, being purely relative, may be misleading. Acquisition of even "basic" capabilities such as quality control, maintenance, scheduling, or reaching prescribed levels of machine efficiency, generally requires considerable expenditure of time and effort. The more advanced capabilities, for adaptation and innovation, generally require higher (or different) skills, more time and greater investment.

Production capabilities include both process technological capabilities as well as product capabilities, such as product redesign, product quality improvement and introduction of new products. In addition, production capabilities also cover monitoring and control functions included under industrial engineering. Industrial engineering skills are required to improve productivity by changing the time and spatial sequencing of manufacturing and auxiliary operations. The introduction of "just in time" systems, for instance, calls for a different form of work organization and procurement — industrial engineering is needed to design and implement such systems.[9] Industrial engineering entails a variety of mathematical, statistical and organizational techniques, time and motion studies, layout and materials-handling analysis. Absence of industrial engineering skills can be an important gap in the technological-capabilities' spectrum.

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[8] On Korea, for instance, see Enos and Park (1987). One of the reasons why Korea is renowned for having low project costs and rapid implementation of investments is that the government made a deliberate effort to develop investment capabilities by helping firms to locate sources of technology and negotiate favorable terms, including the participation of local engineering firms in design and construction.

[9] It especially requires a sophisticated and reliable *distribution system*, which includes a high-confidence legal environment in which contract obligations are met, an adequate transport infrastructure which permits appropriate combinations of modes of carriage, and a tax structure which penalizes warehousing inputs.

Learning Mechanisms

Learning mechanisms constitute the dynamic element of the three types of technological capabilities, enabling firms to change over time the levels of investment and production capabilities. Acquiring new investment and production capabilities, or improving those already at the firm's disposal, are crucial for the firm's future competitive success and survival. The "learning" mechanisms by which individual firms build-up their endowments of capabilities can ultimately determine the parameters of aggregate manufacturing productivity growth and development.

Improvement of technological capabilities in the firm will be influenced by: (i) broad factors, such as government policies toward education, particularly education in science and engineering, which affect the available supply of technical personnel; (ii) efforts inside the firm to promote learning, such as on-the-job training and R&D activity; and (iii) the availability of micro-level learning support mechanisms, external to the firm, which can be drawn on as the firm seeks to build capabilities.[10] These external support mechanisms can be private, in that learning occurs as a by-product of the firm's normal business transactions, or collective, in that the channels for learning are fostered by a collectivity of government, NGO or donor programs to aid firm-level technical efforts.

An example of a purely private external learning channel is the information flow that occurs as the firm transacts business with buyers and suppliers. Valuable information on market requirements, technological improvements and efficient use of machinery is transmitted. The higher the firm's current endowment of technological capability, the greater will be the benefit of such interaction. At another level, technological learning is facilitated by the firm's involvement in an information-rich environment created by a dense network of relations with other firms engaged in similar activities, with training opportunities and information sources that address specific business problems, and with an available network of specialized consultants. The potential learning channels in this environment can be privately or collectively provided, or both. A purely collective support mechanism facilitating capability development might be in the nature of the firm's direct interaction with government technology support institutes, which specialize in particular areas of technology development.

In countries where firm capability endowments are low, where information environments are not rich because vertical and horizontal links between firms are weak or missing, where firms are technologically isolated from the rest of the world and where collective support services are non-existent or poorly delivered, activist strategies aimed at developing both private and collective channels to support learning are required. To a substantial degree, private and collective support mechanisms for learning can be thought of as substitutes. Firms initially meet their technology needs internally, or as a consequence of external business transactions or by way of contracting with providers. When firms are unable to fulfill their needs privately, there will be a demand for collective support

[10] For a detailed study of private and collective technical and marketing support services in East Asia and Colombia, see Levy and others (1994).

mechanisms to fill the gap. Demand for collective support will vary according to the following factors. First, demand for collective technical support is likely to be higher for firms in industries requiring complex production technologies, and lower for firms using craft-based technologies. Second, demand is likely to be greater for all firms when the country is technologically isolated from the rest of the world and when private technology networks and linkages available to firms are weak or missing. Third, demand for collective support channels will be low when industry competition is low and production incentives distorted. Lastly, within industries, demand is likely to vary across firms according to the current availability of private learning channels open to them. *Ceteris paribus*, one might expect two possible situations: (i) some firms with low capability endowments may have problems accessing the available private learning channels; (ii) some firms may be on the fringes of the available networks in the information-rich environment and therefore may not be able to enjoy its potential benefits without some collective support.

On the supply side, the delivery of external collective support can take two different forms. It can be broad-based, in that programs are aimed at nurturing the emergence and development of an "information-rich" environment of learning channels. Alternatively, it can be "high-intensity" and firm-specific, in that programs aim to promote technical learning by supplying technical inputs directly to firms. In practice, of course, a national technology policy might include a mix of such efforts with the objective of building up information-rich learning channels and firm-specific capabilities in particular "strategic" industries. A key variable on the supply side will be the country's institutional capabilities to deliver collective support whichever form of support is chosen. Capabilities of government, NGOs, business associations and international development agencies all play a role. The country's basic infrastructure will also be a supply side determinant.

Technological Capabilities and Firm Productivity

To see how firm-specific technological capabilities interact with other forces to determine measured productivity of the enterprise, one can consider a stylized production function of neoclassical growth theory given by

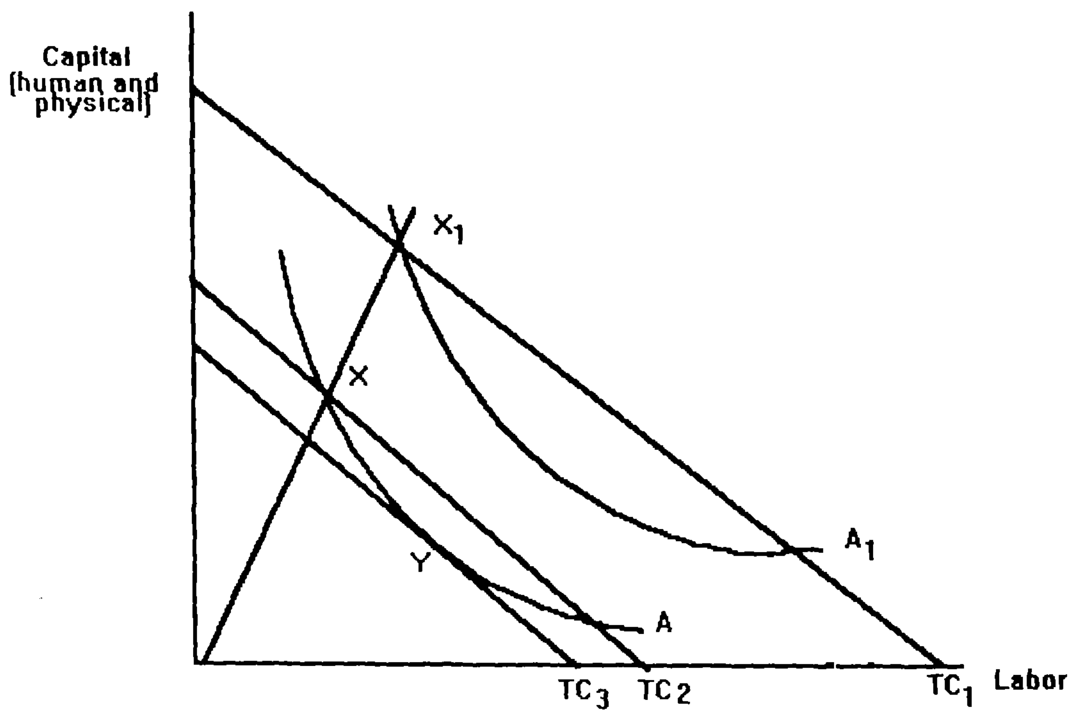
$$Y = Ae^{\mu t} K^{\alpha} L^{1-\alpha} \qquad (1)$$

where Y is gross domestic product, K is the stock of human and physical capital and L is unskilled labor used in production. Technology is represented by the other two parameters: A is a constant reflecting the technological starting point, or the initial static endowment of capabilities, and μ is the rate of evolution of technology. Greater endowments of technological capabilities will allow higher amounts of output from any given levels of input. Similarly, assuming a competitive environment, the stronger the available learning mechanisms internal and external to the firm, the higher will be the learning rate μ.

These technological parameters, which were treated as exogenous in the Solow-type neoclassical growth models, are endogenized in the new theories of economic growth by specifying investment externalities (in both physical and human capital), or increases in the variety or quality of intermediate inputs and machinery, as determinants of technological change. Much of the theoretical modeling in new growth theory has been in the context of industrialized countries with the result that empirical studies have focused primarily on R&D expenditures and investments in human and physical capital as determinants of technological evolution. In the Sub-Saharan economies, in contrast, it is more useful to view the technology terms A and μ in equation (1) more broadly, as related to knowledge embodied in new equipment as well as knowledge encompassing organization routines, flow of materials in a factory, inventory management, and a host of other technological efforts that can enable firms to reach "best-practice" levels of given technologies and that determine the intensity with which industrial technologies already used by firms are changed by continuing adaptation and incremental improvement.

These technological capabilities, by bringing firms closer to best-practice utilization of technologies, have thus a direct impact on the productivity of firms. Diagrammatically, the relationship between technological capabilities and firm productivity can be shown as in Figure 2.1 below.

Figure 2.1
Sources of Enterprise Inefficiency



The "best practice" unit isoquant A represents various combinations of labor and capital stock employed to produce a unit of output in best practice plants throughout the world. A_1, on the other hand, depicts the unit isoquant of firms with lower levels of technological capability. Best practice firms operating along A, at either point X or Y, would have higher

TFP than lower capability firms operating at point X_1 or any other point along A_1. Along A_1, lower skill firms employ higher levels of labor and capital, and therefore have higher costs than best practice firms, to produce one unit of output. Given the prevailing input price ratio of wages to user cost of capital, represented by the slope of total cost lines TC_1, TC_2 and TC_3, for any output level Q we have

$$\frac{Q}{TC_3} > \frac{Q}{TC_2} > \frac{Q}{TC_1}.$$

A priori, there can be two distinct reasons for the reduced TFP of lower capability firms. First, in low capability firms, we are likely to observe lower technological mastery of production engineering, lower research and development expenditures, inadequate quality control, inadequate maintenance of equipment, low expenditures on employee training and so on. In addition, one might also observe shorter production runs and other capacity utilization problems.[11] All these factors, representing lower production capabilities, raise production costs over those obtained in best practice firms for any given technique or combination of factors of production. For example, along the ray OX_1 in Figure 2.1, this *production inefficiency* is reflected as an increase in costs from TC_2 to TC_1 for production at X and X_1 respectively.

Second, low capability firms are likely to have chosen a technique of production, such as X_1, that does not minimize production costs at the prevailing input cost ratio. One would observe in such firms, among other things, lower investment capabilities. That is, lower capabilities to search for, identify and obtain appropriate equipment, and/or lower capabilities to make adequate modifications and adaptations to this equipment to fit the firm's production circumstances. Lower capabilities in this case would lead to *allocative inefficiency* and increase costs above best practice levels by the difference between TC_3 and TC_2.[12]

Reducing costs and raising TFP requires technical efforts on the part of firms to promote learning. Investments in on-the-job training of workers, R&D activity, quality control and production engineering should enhance production capabilities, moving firms closer to best practice isoquant A, from X_1 to X. Reduced production costs (net of training, R&D activity and so on) from TC_1 to TC_2 raises TFP toward levels obtained in best practice firms. Such investments by enterprises themselves, or by way of assistance from governments or donor agencies, may also enhance the firm's ability to alter the proportions in which primary factors of production are employed, allowing the firm to move closer to cost minimizing factor intensities, and further reduce cost. In addition, if firms which have achieved best practice can also replicate and establish a new plant that operates along A, they can be said to have acquired higher investment capabilities.

However, the simple existence of higher technical capabilities in the form of trained and experienced managers and workers does not always guarantee high firm-specific

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[11] There may also be managerial slack or inefficiency. In this context, see also Liebenstein's (1977) discussion of X-efficiency.

[12] See the next chapter for a more precise definition of production and allocative inefficiency.

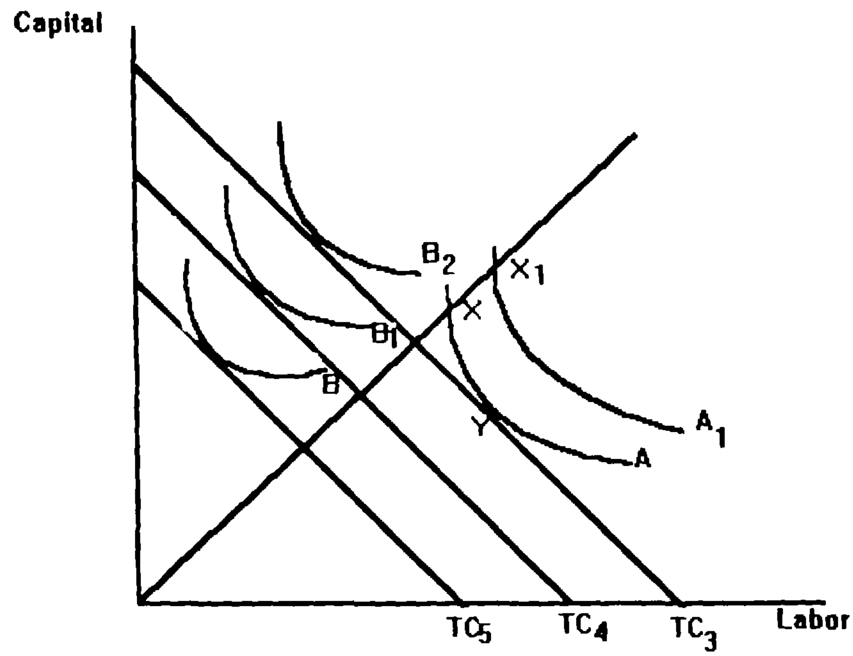
productivity. Reductions in unit cost emanate from explicit efforts at cost reduction. In the absence of competitive incentives to engage in such efforts, firms will generally not strive to increase efficiency. In addition, inefficiencies may be induced by distortions in other industries, influencing the cost and quality of critical production inputs. Infrastructure failures may also raise production costs. Thus, for any given group of firms, the economic environment, together with firm-specific characteristics, jointly determine productivity. Firm capabilities provide the *potential* to raise productivity, but such skills may not be deployed in pursuit of higher TFP without proper incentives. Also, other factors, such as available input quality, infrastructure services and the operation of capital markets, may limit attainable productivity levels even with a highly skilled work force operating at maximum levels of effort.

In terms of Figure 2.1, these factors may have several implications for public policy efforts to raise technological capabilities and shift firms from operating along A_1 toward the best practice unit isoquant A. First, since non-competitive environments generally lead to limited efforts to employ those technological capabilities that are present, interventions to build up capabilities in such environments may have very little impact on productivity.

Second, even where best practice capabilities are present, these skills may simply be devoted to redressing the productivity-depressing effects imposed by distorted policy regimes. For example, engineers may spend their time adapting equipment to cope with low quality inputs made locally because imports are restricted. While this may lead to higher productivity than in the absence of adaptive efforts, these endeavors mainly redress the productivity-depressing effects of policy and the net effect is likely to be small. Thus, if economic policies are not liberalized, hiring more engineers and technicians, or raising the task-level efficiency of workers via training may improve productivity a bit, shifting firms from A_1 toward A, but the magnitude of this gain is likely to be dwarfed by the inefficiencies stemming from the policy regime.

Note that technological capabilities affect not only the static technical efficiency of firms, in terms of best-practice utilization of technologies, but also have an important role in determining firms' *dynamic efficiency*. In the longer run, investing in efforts to raise current TFP within a given industry may also build up experience and create skills that allow firms to produce new, more technologically complex, higher-value products for domestic markets or perhaps for export. The transition to production of more technologically difficult products will be faster and more efficient the greater the available supply of specific technical capabilities needed to manufacture such products. For example, in Figure 2.2 below, a new, higher-value product is introduced with a best-practice unit isoquant shown by B.

Figure 2.2
Capabilities and Dynamic Efficiency



In firms with very low technical abilities in developing countries, the attainable unit isoquant may only be B_2. However, the greater the supply of technical capabilities entailed for producing on B, the faster will be the transition to producing the new good at its best practice isoquant. If firms could move from A_1 to B rather than to B_1, the industrial sector would realize a greater rate of TFP growth. The positive impact of technical capabilities on productivity in this case stems from the heightened ability to deal with technical change that is introduced by the inflow of new equipment and knowledge in new economic activities. At the heart of these productivity gains are the learning mechanisms internal and external to the firm which foster successful absorption of foreign technological knowledge.

Determinants of The Demand For Technology Development

The determinants of technological capabilities may be considered in terms of an incentive framework, which determines the "demand" side of technological capability building, and the "supply" factors. The latter consist of the various factors constituting the learning and collective support mechanisms external to the firm that were discussed earlier. Thus, firms must be able to draw heavily on information from other sources to increase their technological competencies beyond their base levels. These sources include the import of technologies from the advanced countries, advice and services from consultants, information from component and equipment suppliers, competitors, and a range of inputs from the industrial technology infrastructure such as extension services, standards, metrology, basic research, contract R&D, and so on. In addition, access to finance is another critical determinant of the firms' ability to invest in their technological development.[13] These supply side factors determining levels of technology development are the focus of the analysis presented in this report. However, we also briefly note below the factors influencing demand for technology development on part of firms.

What determines the willingness of industrial enterprises in a developing country to invest in their own technological development and to seek information, skills and other resources from other enterprises and institutions? A firm faces a set of market and non-market incentives that determine the "demand" for technological effort. The most fundamental incentive for a firm to develop its technological capabilities arises initially from the need to get into production. This is true regardless of the nature of the trade and industrial regime, as long as the firm wants to succeed commercially and has the managerial autonomy to invest in technological capabilities. However, the extent to which it invests in its capabilities and the extent to which it sustains its efforts to adapt to changing conditions and diversify or deepen its base of capabilities depend on incentives offered by the market place. The macroeconomic environment and growth prospects for major markets, domestic or foreign, clearly exert a strong influence on decisions to invest. A stable and high growth environment is more conducive to investment than other environments.

The international or "frontier" rate of technological progress will also affect the pace and content of technological capabilities. No modern manufacturing technology is static, and no country can afford to ignore world technological trends if it wishes to achieve international competitiveness in some manufacturing activities. The rate of technical change is very different across activities, and the incentives offered for increasing technological capabilities vary accordingly.[14] In all cases, even when the change originates elsewhere, indigenous technological effort is critical to coping with technical progress, since this is what determines how effectively local enterprises can deploy the new technologies in production.

Competition, domestic and foreign, is perhaps the most important incentive to increase technological capabilities. Competitive markets provide some of the most potent stimuli to investments in capability acquisition. Hence, artificial restraints to competition may hold back investments in technological capabilities, or may lead firms to develop the wrong kinds of capabilities. Many developing countries have imposed such restraints in the form of barriers to entry by investment licensing, entry controls by size, ownership requirements, restraints on firm growth or diversification, and so on. Full domestic competition by itself may not be sufficient to stimulate investment in technological capabilities if firms are protected from foreign competition. Exposure to world competition is

[13] For example, underdeveloped financial markets may be unable to finance training activities, R&D, and other expenditures not directly related to working capital. Further, smaller firms facing greater barriers to financial access may be restricted in their ability to invest in human capital or technological upgrading.

[14] In some activities, the import of equipment combined with some local design and absorption effort may suffice, while in others considerable licensing and local R & D may be necessary. Similarly, in some industries, low wages and the use of somewhat older technologies may allow the country to preserve its competitiveness; in others, the utilization of state-of-the-art technologies may be essential.

hence another powerful incentive for industry in developing countries to invest in technological capabilities.[15]

Lastly, other incentives to investment in technological capabilities arise from factor markets. Changes in relative factor prices and availability can lead to considerable technological activity as firms adjust factor intensities in response. Furthermore, inflexibility and uncertainties in labor markets can also retard or distort the pattern of investment and capability building, as can imperfections in capital markets.

[15] External competition is, however, a double-edged sword and, given the necessary costs of learning, can stifle capability building in newcomers. A common, but risky, response to this problem has traditionally been erection of national trade barriers to protect new industries.

3. Technical Efficiency of Manufacturing Enterprises in Africa

The implementation of structural adjustment programs in Sub-Saharan economies has resulted in liberalized trade regimes and greater exposure of domestic firms to external competition. This trend is likely to continue over time as further measures liberalizing the trade account are implemented in these economies. The extent to which domestic manufacturing firms are competitive in the face of growing international exposure is therefore a critical issue affecting their ability to survive and grow in the future. Yet not much is known about manufacturing productivity in Sub-Saharan Africa. While there is a general presumption that levels of the skills and abilities needed by firms to efficiently organize production are low in Sub-Saharan Africa, much like most other development indices in these countries, empirical evidence on this issue is extremely limited.[16] Consequently, in this chapter, we undertake a comprehensive analysis of measured productivity of manufacturing firms in three countries — Ghana, Kenya and Zimbabwe — using primary survey data collected by RPED.

A number of interesting issues with important policy implications arise in the context of analyzing manufacturing productivity. To begin with, the levels of relative technical efficiency of firms have direct implications for the scope and pace of trade policy reforms in the economy.[17] Thus, relatively low levels of productivity in African enterprises would suggest greater difficulties for these firms as they seek to compete with the more efficient, or low-cost, foreign firms. An obvious implication in such case would be a lower ability of domestic firms to survive extensive trade liberalization, raising the possibility of significant de-industrialization within these economies. Conversely, relatively small productivity gaps between domestic firms and their external competitors would enhance the prospects of a smoother and more rapid transition to fully liberalized trade regimes.

Secondly, a key set of policy issues revolve around the relationship of inter-firm productivity differentials to firm size and employment creation. Researchers and policy makers have often associated the capacity to create employment with firm size. In developing economies, for example, microenterprises and small firms have often been viewed as important elements in the objectives of employment generation and poverty alleviation. Data available in the RPED surveys allow us to investigate whether or not small firms are relatively more labor intensive, thus economizing on capital, the scarce factor. Another important question in this context is whether smaller firms have higher productivity than larger ones. The relative efficiency between firm size classes can help policy makers identify enterprise groups with the highest potential for meeting planned economic targets as well as provide useful inputs into other government policies, such as those attempting to maximize gains from targeted credit programs or from technical assistance programs.

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[16] Page (1980) provides estimates of total factor productivity in wood-working and furniture making in Ghana. Another relevant study is Pack (1987), which estimates total factor productivity in textiles in Kenya.

[17] The terms "technical efficiency" and "productivity" are used interchangeably: as will be seen below, the measure of technical efficiency adopted in the analysis is the same as total factor productivity.

Finally, an important range of policy issues stem from analyzing the determinants of inter-firm variations in total factor productivity. What makes one firm more efficient than another? What policies can have the greatest impact on increasing firm productivity in the economy? Of special interest in this context is the relationship at the firm level between technological capabilities and technical efficiency. Do technological capabilities of firms contribute to increased technical efficiency? If so, what type of technological capabilities are relatively more important? Empirical analysis of these issues in the context of African manufacturing is virtually non-existent and would therefore provide useful insights into formulating policies for increasing manufacturing productivity in these economies. Indeed, to the extent sustained economic growth is associated with rapidly growing levels of productivity, answers to these questions can contribute significantly to enhancing the long term growth prospects in Sub-Saharan Africa.

The data utilized in this chapter come from a primary survey conducted by RPED in Ghana, Kenya and Zimbabwe. A large-scale survey questionnaire was administered to a random sample of firms in each country: 164 firms in Ghana, 224 in Kenya and 200 in Zimbabwe. The firms, varying in size from microenterprises to some of the largest firms, are in one of four sectors of activity: food and food processing, textiles and garments, wood working, and metal working. The RPED surveys were conducted in Ghana in 1992 and in 1993 in the other two countries.[18]

The organization of this chapter is as follows. In evaluating relative technical efficiency of African manufacturing firms, ideally one would like to assess how close or far these firms are from international frontiers defined by best-practice production in different sectors of activity. Unfortunately, strict measurement of gaps in total factor productivity between African manufacturing enterprises and international best practice norms is not possible given the data available. However, we do have available data to measure labor productivity and capital productivity across countries. Consequently, the next section presents summary data on labor and capital productivities in the surveyed African firms in comparison with similar figures from three Asian economies. Given the virtual absence of relevant stylized facts on African manufacturing, this exercise highlights the extent to which African manufacturing firms conform to specific patterns also found elsewhere in the world. Specifically, economic theory predicts certain well defined relationships among firms between different factor intensities and partial factor productivities (average products of labor and capital), patterns that have been documented across firms in the rest of the world but not yet in Africa. The comparisons in Section 1 clearly indicate that the structure of African manufacturing is quite similar to that elsewhere in the world.

However, notwithstanding the similarities in structure, the *levels* of total factor productivity in African firms may still be much lower than their international counterparts. Consequently, in the following section, a detailed analysis of total factor productivity is undertaken. A brief discussion of the theory and econometric methodology underlying stochastic production frontiers is presented followed by a discussion of the empirical

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[18] For futher details on the data utilized, including sample designs and basic firm attributes, see the next chapter and the subsequent country case study chapters in Part II.

estimates of technical efficiency by sector and across the three countries. Although, as noted, direct international comparisons are not feasible, results of similar estimates for other countries are provided where ever possible. Furthermore, based upon best-practice frontiers in the three sampled countries, direct comparisons of total factor productivity are presented across sectors, firm sizes and country. In the third section, the analysis focuses on determinants of inter-firm productivity differentials. The sources of inefficiency driving these differentials are analyzed econometrically with a special focus on the role of technological capabilities in determining firm efficiency. The penultimate section of this chapter looks at the same issues as in the previous section but now specifically in the context of small and microenterprise firms, which constitute the greatest number of manufacturing firms in Africa. Finally, the chapter concludes with a brief summary of the main empirical findings.

Partial Factor Productivities and Factor Intensities

Table 3.1 below presents data on factor intensities and partial productivity measures across firms of different sizes in Zimbabwe, Kenya and Ghana as well as, for the purposes of comparison, in three Asian economies. [19]

In South Korean manufacturing firms in Table 3.1, labor productivity rises almost monotonically with firm size. Although capital intensity also rises monotonically, it does so more slowly than the increase in labor productivity, and is virtually constant in the range of 10-200 workers. Capital productivity, on the other hand, is also virtually constant, in the range of 5-50 workers, and then rises dramatically for the next two size classes before falling back for the largest size class. Partial productivity of capital thus shows an inverted U-shape.[20] In addition, comparing the size class of firms with 100-199 workers to that with 10-19 employees shows a rise of about 120 percent in both labor and capital productivity and virtually no change in capital per person. This size class, therefore, clearly dominates in terms of productivity the others in South Korea.[21]

[19] Given the assumption of constant returns to scale, perfect competition and equal rates of return on capital amongst all firms, increases in capital intensity across firms will be associated with increases in labor productivity and decreases in capital productivity.

[20] The inverted U-shape has also been observed in case of Japanese manufacturing firms (Little and others 1987).

[21] Note that while increasing factor productivities with increasing firm size may result from exploiting economies of scale, they may also result from the existence of monopolistic markets: since the numerator "Y" in Table 3.1 is value added, monopolistic conditions may allow higher value added for smaller inputs of capital and labor, thus implying increases in labor and capital productivity as firm size increases. However, if increasing monopoly underlies the higher productivities of the larger firms, it would be difficult to reconcile it with decreases in these figures for the highest size classes. Consequently, the relatively lower performances of the largest firms can be attributed to a decreasing scope for exploiting scale economies.

Table 3.1
Factor Intensities and Productivities in Asian and African Countries

Firm	*South Korea*			*India*			*Thailand*			*Zimbabwe*			*Kenya*			*Ghana*		
Size	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*
5-9	296	0.66	196	—	—	—	86	0.26	23	2042 (15)	1.92	3734	2612 (13)	1.41	2200	430 (13)	1.28	507
10-19	375	0.66	248	8.81	0.44	3.84	68	0.43	29	1333 (7)	2.19	2952	6104 (7)	0.94	3869	2442 (11)	1.11	683
20-49	388	0.67	259	8.47	0.48	4.06	"	"	"	8131 (15)	1.10	4528	7885 (18)	0.83	3395	5189 (19)	0.89	1807
50-99	387	0.81	315	8.68	0.51	4.42	78	0.60	47	9581 (23)	0.68	4750	7352 (22)	0.89	3588	2691 (7)	0.93	1575
100-199	380	1.45	553	14.46[a] 10.60[b]	0.45[a] 0.87[b]	6.57[a] 8.76[b]	88	0.59	52	6884 (22)	1.41	5613	17092 (13)	0.76	6774	3197 (4)	1.03	1735
200+	520	1.17	607	18.45[b]	0.86[b]	15.86[b]	216	0.37	80	11160 (37)	1.00	7721	15123 (16)	0.53	4540	9868 (5)	0.28	1918

Note: K = Capital; L = Labor; Y = Output.

Korea
Source: I.M.D. Little, D. Mazumdar, and J. Page, Jr. (1987). *Small Manufacturing Enterprises — A Comparative Analysis of India and other Economies.* World Bank Research Publication, New York: Oxford University Press, Table 7.1.
Figures in 1000's of Won. Ratios for Year 1968.
K = Market Value of Tangible Fixed Assets, including Land.
200+ @ 200-499

India
Source: I.M.D. Little, D. Mazumdar, and J. Page, Jr. (1987). *Small Manufacturing Enterprises — A Comparative Analysis of India and other Economies.* World Bank Research Publication, New York: Oxford University Press, Table 7-5.
Figures in 1000's of Rs. Ratios for 1974-77.
K = Book value of K.
[a] Values for 100-499
[b] Ratios using only fixed K from Table 7-6

Thailand
Source: I.M.D. Little, D. Mazumdar, and J. Page, Jr. (1987). *Small Manufacturing Enterprises — A Comparative Analysis of India and other Economies.* World Bank Research Publication, New York: Oxford University Press, Table 7-3.
Figures in 1000's of Baht. The smallest size category covers 0-9 workers.
Firms with 10-49 workers constitute one category.

Zimbabwe, Kenya and Ghana
Source: RPED Survey Data, 1992-93.
Ratios for 1992 in Ghana and 1993 for Kenya and Zimbabwe. Figures are in US dollars.
Figures in parentheses refer to number of observations in the category.

Data for Thailand also display an inverted U-shape for capital productivity. The smallest size class shows relatively high capital intensity which varies little until the largest size class when it leaps up. But both capital and labor productivities increase until somewhere in the range of 50-200; hence the smaller firm sizes indicate lower productivity than larger firms. In India also, the small firms in 10-19 size class have a slightly higher capital intensity and lower factor productivities than firms in the 50-99 category.[22] Indeed, up to about 100 workers, capital intensity is virtually constant while both factor productivities increase showing that larger firms dominate the smaller ones. Both capital intensity and labor productivity for the Indian firms show a sharp rise in the size above 100 workers. In Table 3.1, the first set of figures for firms with more than 100 workers refer to the size category of 100-499 workers. A finer partition of this size category is available from an alternative source but using a different measure of capital. These figures are also presented in the table and show that the sharp rise in capital intensity and labor productivity occurs in the neighborhood of 200 employees.

For the three Asian economies, therefore, two general conclusions follow from these figures. Firstly, manufacturing as a whole shows little evidence that the smallest firms (0-10 workers) are the most labor intensive or have the highest capital productivity, the relatively scarce factor in industrializing countries. In Thailand, the smallest size group is not the most labor intensive while in India the labor intensity is higher in the range of 20-99 workers than in the 10-19 category. Secondly, in all three Asian countries, the size category 100-199 appears to dominate all others for firms in the range of 20 to 200 workers. A reason to focus on this range for comparison is that data on firms with less than 20 employees can be somewhat noisier, especially for the microenterprises and other very small informal-sector firms, while very large firms (with more than 500 workers) in many cases present only a few observations.

Turning next to the African economies, it should be noted that the data on African firms in Table 3.1 include only four industries while for the other countries, the data refer to manufacturing as a whole.[23] In general, disaggregation of overall manufacturing ratios into separate industries is expected to show fewer regularities between factor intensities, productivities and firm size. However, as will be seen in Table 3.2 below, the four industries represented in the African firms' data do seem to display the expected regularities albeit when pooled across all three countries.[24] Data on the three African countries in Table 3.1 at

[22] Data on firms with less than 10 employees are available from a different survey and suggest that the capital intensity of these firms is marginally higher than that for firms with 11-20 employees, with both factor productivities lower in firms with 6-10 employees. See Little and others (1987), Table 7-7.

[23] However, these four industries account for approximately 70-80 percent of manufacturing employment and about 80 percent of manufacturing output in African countries.

[24] Analysis at specific industry level is not possible within any of the three countries due to the incidence of cells with too few observations. Note that the data presented in this and the next table are based on a substantially smaller sub-sample of all firms covered by the RPED surveys. The sub-sample represents only the firms included in the estimation of stochastic production frontiers later in this chapter. While this makes the sample a bit smaller than it could otherwise be, it also increases the comparability of factor intensities and partial productivities here with the later analysis of total factor productivities.

first glance appears to show little evidence of systematic patterns in capital intensity and factor productivities across all the firm sizes. A more careful analysis, however, highlights considerable similarities between the African firms and the data for the Asian countries in Table 3.1. In particular, focusing separately on firms with less than 20 workers versus all other firms reveals four interesting features of the data that are noteworthy.

Firstly, the dualistic nature of African manufacturing is clearly evident in the dramatic increase in capital employed per unit of labor when moving up from the smallest size categories. In Zimbabwe, capital intensity of firms with 20-59 workers is almost four times that in the smallest firms. In Kenya and Ghana, a similar break occurs between firms with less than 10 workers and the size class 10-19, with the jump in Ghana equaling a factor of almost six times. Notwithstanding possible inadequacies of data for the smallest size firms, the orders of magnitude of these changes in capital intensity are dramatic, especially when compared to the Asian economies. In light of the relatively strong dualism manifested in these structural breaks, it is perhaps not surprising that the smallest firms are the most labor intensive in all three African countries, in contrast to the data on Asian manufacturing firms.

However, if we consider firms with at least 20 employees, there is no presumption that smaller firms are more labor intensive than larger ones. To that extent, firms in the 'modern' sector (i.e., excluding the microenterprises and other informal small firms) of these African countries appear remarkably similar to their Asian counterparts. Although capital intensity on the whole rises monotonically with firm size in all three African countries, in no case is the size class 20-49 the most labor intensive category. Further, as in the case of Asian manufacturing, labor productivity also rises monotonically with capital intensity, and partial productivity of capital clearly displays an inverted U-shape (with 20-49 category in Zimbabwe the only exception).

A third interesting aspect of these data also highlights the similarity of the African manufacturing firms with those in Asian countries. Once again, firms in the size class 100-199 are found to be relatively dominant in all three countries although marginally less so in Kenya than in Zimbabwe and Ghana. Thus, in Zimbabwe, firms with 100-199 workers display a lower capital intensity and higher factor productivities than all smaller-sized firms with at least 20 employees. Even compared to the largest firms, the firms in 100-199 category have little more than half the capital per employee with partial capital productivity 41 percent higher in comparison, compensating for the lower (27 percent) labor productivity. In Kenya also, both factor productivities peak in the range of 50-200 employees while in Ghana, firms with 100-199 employees have relatively high labor intensity, the highest capital productivity and labor productivity comparable to all other size classes. In sum, therefore, patterns of factor intensities and productivities among the African manufacturing firms do not appear markedly different from those displayed by their Asian counterparts.

Lastly, since the figures for all three African countries are converted into US dollars, we can (roughly) compare across the countries and note that firms in Zimbabwe have much higher factor productivities in each size class except 50-99 workers.[25] Conversely, firms in Ghana have the lowest partial productivity for labor in each size class while capital productivity is lowest amongst the Kenyan firms in the range of 20-200 workers. Firms in Zimbabwe also have the highest capital employed per unit of labor in the range of 20-100 workers, while capital intensity of the largest firms is much higher in Kenya than in the other two countries.

Finally, to complete the description of partial factor productivities and factor intensities in the sampled firms, Table 3.2 summarizes the behavior of these variables across the four sectors. As noted earlier, disaggregated, industry-level data in other countries tend to show fewer empirical regularities between factor productivities and factor intensities than for manufacturing taken as a whole. For the four sectors represented by these firms, however, data in Table 3.2 indicate relatively few deviations from the regularities expected at higher levels of aggregation.

Across industries, capital intensity increases monotonically with firm size for the most part if firms with less than 20 employees are again considered separately. The structural break in capital intensity occurs at the level of 20 workers for firms in food and garments sectors while, in the other two sectors, capital intensity jumps up at a smaller size of 10 or more employees. In terms of factor productivities, labor productivity appears to grow monotonically with size while capital productivity does not indicate the inverted U-shape typically encountered at higher levels of aggregation. Among firms with at least 20 employees, food processing and metal working firms show much higher levels of capital intensity in each size class than firms in the other two sectors.

Except for the food sector, one size class dominates all others in the remaining three sectors. In garments and metal working, firms with 100-199 workers have the highest factor productivities while in furniture the factor productivities are the highest among firms in the 50-99 category. The lowering of factor productivities in the largest firm sizes can be viewed as suggesting limitations in the scope for exploiting scale economies beyond a certain size -- an empirical regularity observed in other countries in Asia and Latin America also. Only in the food sector are the largest-sized firms found to have relatively high factor productivity levels.

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25 The nominal values in each country were converted using the official exchange rates. Since all three countries have undergone substantive policy reforms in external accounts, the official exchange rates were quite close to market rates. For example, premiums in the parallel markets were very small in all three countries at the time of the RPED surveys.

Table 3.2
Factor Intensities and Productivities in African Manufacturing by Sector

	Food			*Textiles & Garments*			*Furniture*			*Metal*		
Firm Size	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*	*K/L*	*Y/K*	*Y/L*
5-9	3,771	2.16	5,615	1,123	0.89	761	1,048	1.75	730	795	1.06	1,029
	(10)			(8)			(12)			(10)		
10-19	3,372	1.22	1,313	1,314	1.29	1,636	3,396	1.11	4,013	7,401	1.16	1,628
	(7)			(10)			(3)			(4)		
20-49	8,419	0.98	4,353	5,867	1.11	2,293	4,421	0.72	1,715	8,919	0.83	3,792
	(18)			(11)			(10)			(14)		
50-99	12,238	0.54	3,871	7,128	0.70	3,309	5,284	1.10	3,046	9,775	0.71	5,245
	(9)			(15)			(15)			(15)		
100-199	13,297	0.83	7,827	8,876	1.61	5,181	4,563	0.89	2,622	8,943	1.27	6,186
	(9)			(11)			(8)			(10)		
200+	12,984	0.89	8,937	9,564	0.86	4,330	5,453	0.91	2,773	15,767	0.62	8,253
	(17)			(23)			(5)			(12)		

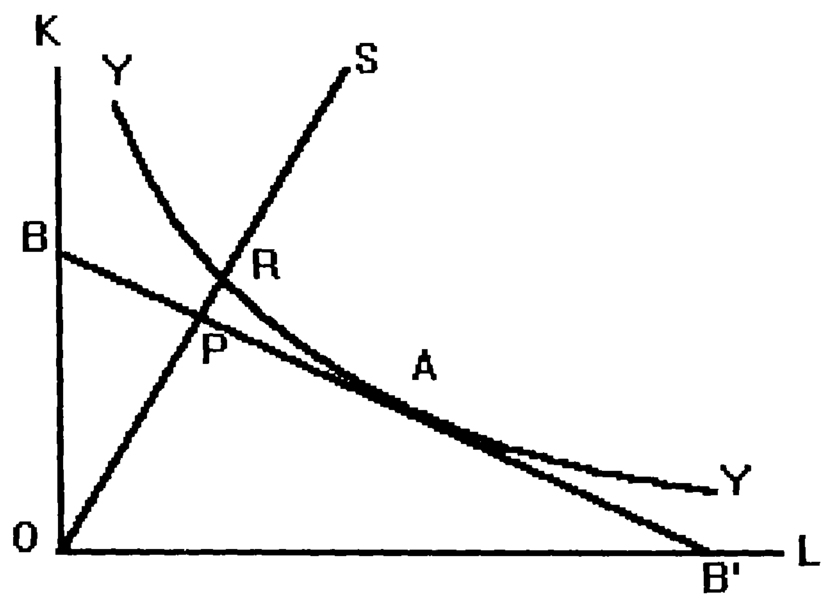
Note: K = Capital; L = Labor; Y = Output.
Figures in parentheses refer to number of observations in the cell.

Source: RPED Survey Data, 1992-93.

Total Factor Productivity in Manufacturing

We now turn to a detailed analysis of a broader measure of firm productivity using the concept of technical efficiency, which provides a measure of total factor productivity. A production unit is defined to be technically inefficient if it is obtaining less than the maximum output available from whatever combination of inputs it chooses to employ. Consider, for example, the unit isoquant in Figure 3.1 below which depicts a constant returns to scale activity in terms of the minimum combinations of inputs required to produce one unit of the activity's output. If the factor price ratio is represented by the line BB', then point A on YY indicates the least costly combination of inputs for producing any given quantity of output.

Figure 3.1
Measurement of Technical and Allocative Inefficiency



Note: K = Capital; L = Labor.

If a firm uses another input combination to produce at a point such as S, its inefficiency can be measured along the ray OS as the excess cost of producing that output over the minimum feasible, i.e., SP/OP. Following Farrell(1957), this quantity can be decomposed into two elements. For the same input proportions as at S, i.e. along the ray OS, the point R represents the minimum feasible cost of producing the given output and SR/OR is the proportional excess cost of inputs used. This is called "technical inefficiency" of the firm producing at S. Although R is the technically efficient combination of inputs, it is not the least cost combination if factor prices are BB'. RP/OP thus denotes the proportional excess cost due to the use of inappropriate input proportions (too much capital and too little labor in the figure above). This magnitude is referred to as "allocative" inefficiency.

The measurement of technical efficiency in practice is impeded by certain important problems. For example, not all firms may have access to the same technology. If this is the case, then there is no basis for measuring technical efficiency relative to a single frontier since each firm may be efficient with respect to its own set of production possibilities. Similarly, if the factor markets are not competitive but fragmented, the firms may face different factor-price ratios which would again lead to bias in measured levels of inefficiency if the measurement is based on prices other than those faced by specific firms. Another important problem may occur if several vintages of technology coexist within a single industry which would again vitiate the existence of a single production frontier. Although the variation in vintage of the machinery is not high among firms in the three sampled countries, with most firms using fairly old equipment as seen in the case studies later, these conceptual problems may introduce biases in our estimates of technical efficiency whose magnitudes are difficult to quantify.[26]

Technical inefficiency can be estimated empirically using either deterministic frontier models, including the method of Data Envelopment Analysis, or the stochastic frontier approach.[27] Both methods have their own advantages and disadvantages. Thus, deterministic frontier models, utilizing linear programming techniques to essentially wrap a convex hull around the observed production points, have the advantage of being non-parametric in that no assumptions are required about the form of the technology, (Ali and Seiford, (1993)). At the same time, these models also assume that all deviations of an observation from the theoretical maximum are attributable to technical inefficiency. Consequently, a fundamental problem with these models is that any measurement error as well as any other source of stochastic variation in the dependent variable must be interpreted as reflecting technical inefficiency. Hence, outliers can have a dramatic effect on the fitted estimates.

On the other hand, stochastic frontier methodology is not non-parametric and entails assumptions about specific functional forms. At the same time, under the stochastic frontier approach, a frontier or best practice production function is assumed to be determined both by technological parameters as well as by random external factors such as equipment failures, bad weather, or unexpected disturbances in a related market. The interpretation, consequently, is that the production frontier is itself stochastic and that particular outcomes may lie below or even above it depending upon a collection of stochastic elements outside the control of the producer. Since the data in our sample of African firms show a fairly high degree of dispersion across firms of different sizes, and in view of the possibility of significant noise in the data for very small firms in the sample, we have chosen to use stochastic frontier estimates in analyzing productivity levels in the three countries.

[26] See Page (1980) for a discussion of these issues.

[27] Since the literature on measurement of technical efficiency is by now quite well developed, we provide here only a brief discussion of the methodology employed in the chapter. More detailed discussions of these issues can be found in, for example, Caves (1992) and Schmidt (1985).

The stochastic frontier model can be represented formally using a conventional production function y = f(x) where y is the output and x is the vector of inputs. The Farrell measure of technical inefficiency TE is defined as:

$$TE(y,x) = \frac{y}{f(x)}$$

which is also the conventional measure of total factor productivity. The econometric specification based on this equation can then be presented in terms of the output of the i^{th} firm (y_i)as

$$y_i = f(x_i, \beta) TE_i e^{v_i} \qquad (3.1)$$

where $0 < TE(y_i, x_i) < 1$, β is a vector of parameters of the production function to be estimated and v_i is the conventional error term, distributed normally with mean zero and variance σ_v^2. Equation (3.1) can be used to estimate the stochastic production frontier using a composite error as below --

$$y_i = f(x_i, \beta) \exp(\varepsilon_i) \qquad (3.2)$$

where the error term ε_i is composed of two terms:

$$\varepsilon_i = v_i - u_i, \quad \text{with } u_i \geq 0.$$

Both elements of the composite error term ε are assumed to be distributed independently and identically (iid) across the observations. As before, v_i represents the usual error term reflecting random elements, including measurement errors, minor omitted variables, and other factors beyond the control of firms. The component u_i, in contrast, is a one-sided error term capturing technical efficiency, given by the ratio of observed output to frontier output, i.e.,

$$TE_i = \frac{y_i}{f(x_i \beta) \exp(v_i)} = \exp(-u_i). \qquad (3.3)$$

Since only the composite error (ε) is observed, inference about u_i has to be obtained indirectly by making additional assumptions about its specific distribution.. Following Jondrow and others. (1982), u_i is assumed to follow a half normal distribution, satisfying the condition $u_i > 0$ for a firm whose output lies below the frontier. Then firm-specific efficiency for each observation in the sample is given by the mean of the inefficiency error (u_i) conditioned on the total error (v_i-u_i). Thus, dropping the subscript i,

$$E[\hat{u}|v-u] = \frac{\sigma_u \sigma_v}{\sigma}\left[\frac{f(\varepsilon\lambda/\sigma)}{1-F(\varepsilon\lambda/\sigma)} - \frac{\varepsilon\lambda}{\sigma}\right] \qquad (3.4)$$

where E is the expectation operator, $\sigma=\sqrt{(\sigma^2_u+\sigma^2_v)}$, $\lambda=\sigma_u/\sigma_v$, and f(.) and F(.) are the standard normal density and the distribution functions respectively. This yields unbiased point estimates of an efficiency parameter for the decision making unit as:[28]

$$\hat{TE}_i = \exp[-\hat{u}_i] \qquad (3.5)$$

In terms of the *average* technical efficiency of the sample, one estimate often used is given by $\lambda=\sigma_u/\sigma_v$. The greater the relative magnitude of the numerator, the greater the proportion of total variance in the data explained by variations in technical efficiency relative to other random effects. Specifically, the proportion of the total variance attributable to variance of the residuals measuring technical inefficiency is given by --

$$\frac{Var(u_i)}{Var(\varepsilon_i)} = \frac{[(\pi-2)/\pi]\sigma^2_u}{[(\pi-2)/\pi]\sigma^2_u+\sigma^2_v} \qquad (3.6).$$

However, a more natural estimate of average technical efficiency is suggested by Battese and Coelli (1988) and calculated as the unconditional mean of TE_i, i.e., $E[\hat{TE}_i]$. This is the measure adopted in the analysis below, although the ratio above and λ are also presented with the econometric results.

The specific form of the production frontier estimated is a log-linear Cobb-Douglas function as follows:

$$\log Y_i = \beta_0 + \beta_1 \log L_i + \beta_2 \log K_i + \beta_3 \log X_i + v_i - u_i \qquad (3.7)$$

where Y_i measures value added, calculated as total value of output minus raw material and indirect costs, labor L is measured by the total number of employees in the enterprise, and K denotes capital stock measured by its replacement cost. The additional variables, X, in the specification include are two composite variables to adjust for the quality of labor and capital aggregates. The two quality-related variables included are the ratio of non-manual workers to total workers and the rate of capacity utilization. The rationale for their inclusion follows from the fact that labor and capital in equation (3.6) are aggregated over two categories: labor is the unweighted sum of two types of workers in the firms, namely, manual and non-manual workers while the figures for capital stock do not adjust for the amount of capital actually

[28] The estimates are unbiased but inconsistent because their variance remains non-zero regardless of sample size, (Jondrow and others 1982).

utilized. Following Griliches and Ringstad (1971), inclusion of the ratio of non-manual to total workers allows for the requisite correction if skill levels of workers in the two categories are not identical. Similar considerations hold for the inclusion of the rate of capacity utilization to correct for differential contribution of utilized and unutilized capital stock to the production process.[29]

Estimates of technical efficiency across firms in different sectors and countries are presented under three types of specifications. The most extreme case assumes that all four industries in all the countries utilize the same Cobb-Douglas production technology (except for an intercept term). This specification, used by Davies and Caves (1987), allows pooling of all firms in the three countries. The assumption in the second case is weaker, namely that the coefficients of each industry's production function are the same in all countries but not across industries. This is equivalent to assuming that the manufacturing activity in any particular sector in each country represents a more or less efficient branch of the same (international) industry. By fitting a stochastic frontier specific to each sector, we cannot compare across the four sectors. Instead, this formulation enables comparisons of relative technical efficiency of firms across the three countries. Finally, and analogously, the third case pools firms across different sectors in each country assuming, therefore, that all industries share the same production technology within a country but that the technology can change across countries. This allows comparison of inter-sectoral efficiency in each of the three countries represented in the study.

Relative Technical Efficiency of Firms in Ghana, Kenya and Zimbabwe

Table 3.3 below presents maximum likelihood estimates of the stochastic production frontiers for the overall sample.

For the sample as a whole, all coefficients of factor inputs are highly significant as are those for the two quality-related variables, i.e., capacity utilization rate and the proportion of manual workers in total firm employment. Since the assumption of identical technology across all countries and sectors requires constant returns to scale, we test the null hypothesis that coefficients of K and L add to one. This yields a Wald statistic equal to 0.06, which is insignificant even at 10 percent level of significance, and tells us that the assumption of identical technology across countries and sectors cannot be rejected. The average technical efficiency for the full sample of firms given by these estimates is 0.42 which is low. This result suggests that firms are, on average, poor performers compared to the most efficient firms within these countries. The relative inefficiency of African firms would, therefore, be even larger in magnitude if we could calculate this efficiency index relative to the global best

[29] Specifically, let $x=x_1+x_2$ be an aggregated variable (L or K) and the question is whether or not x_2 (non-manual workers or amount of capital actually utilized) is given the "correct" weight. Let $x^* = x_1 + (1+\delta)x_2$ be the "correct" aggregate. Then $x^* = x(1+\delta\phi)$ where $\phi = x_2/x$. If the incorrect aggregate x is used in a log-linear specification, this amounts to leaving out of the equation $\log(1+\delta\phi)$ where δ is the implicit "premium" (or discount). For not too high values of δ, the excluded term approximately equals $\delta\phi$. See Griliches and Ringstad (1971) for further details.

practice frontier. Similarly, the proportion of total variance attributable to the inefficiency term u_i is correspondingly large, equaling almost 70 percent. This suggests that there is a great deal of heterogeneity in productivity across firms in Africa. In more developed economies, estimates of cross-firm efficiency do not exhibit such a wide dispersion. Reducing this heterogeneity in efficiency via the reallocation of resources away from less efficient firms to more efficient firms and sectors can potentially be the source of significant growth in aggregate productivity and incomes. Note also that if, following Caves (1992), the intercept shifts due to dummy variables are interpreted as reflecting changes in a catch-all efficiency term, these estimates indicate the food processing sector to be relatively more efficient than all others whose dummy indicators have insignificant coefficients.

Table 3.3
Stochastic Frontier Estimates for Full Sample

	Full Sample
Constant	3.89*
	(.31)
Capital	0.44*
	(.03)
Labor	0.72*
	(0.06)
Capacity Utilization	0.38*
	(.19)
Ratio Manual to Total Labor	1.93*
	(.37)
Food	0.34*
	(.13)
Wood and furniture	-0.18
	(.12)
Metal	0.10
	(.13)
σ_u/σ_v	2.48*
	(.56)
sqrt($\sigma^2_u+\sigma^2_v$)	1.39*
	(.08)
ATE	0.42
Share of σ^2(u)	0.69

Notes: *ATE = Average Technical Efficiency*
Figures in parentheses are standard errors.
* Significant at 5 percent or less level of significance.
Source: RPED Survey Data from Zimbabwe, Kenya and Ghana, 1992-93.

In Table 3.4 we present the average technical efficiency of firms across the three countries based on the estimated stochastic production function for the full sample.

Table 3.4
Average Technical Efficiency of Firms by Country

Country	*Average efficiency*	*Standard deviation*	*Minimum*	*Maximum*
Ghana	0.33	0.20	0.01	0.77
Kenya	0.41	0.20	0.04	0.82
Zimbabwe	0.52	0.17	0.09	0.82

Source: RPED Survey Data, 1992-93.

These estimates show a clear gradation between the three countries with firms in Ghana showing the lowest levels of average technical efficiency and those in Zimbabwe the highest. Note, though, that the extreme upper values of firm-level efficiency are very similar in each of these countries, indicating the existence of some very efficient firms in each of them. In contrast, the minimum values of estimated technical efficiency are much lower for Ghana and Kenya compared to Zimbabwe, indicating the survival of very inefficient firms in these countries. In short, Ghana and Kenya continue to exhibit much more heterogeneity in productivity in their enterprise structures than does Zimbabwe.

The relative technical efficiency of firms in the three countries can also be compared by estimating stochastic production frontiers for each sector under the assumption that each country's manufacturing activity in that sector represents a more or less efficient branch of the same international industry. Given the same sector-specific production functions across countries, we can test for intercept shifts using dummy variables for the countries. These intercept shifts can then be viewed as revealing changes in a catch-all technical efficiency term across countries.[30] The results of these frontier production regressions are reproduced in Table 3.5 below.

Again these estimates appear to provide reasonably good fits for the production function. Both capacity utilization and proportion of skilled labor are again positive in all countries but are now insignificant except for the latter variable in the wood and furniture sector. Coefficients of the country dummy variables provide estimates of intercept shifts in each industry relative to that in Ghana which is the excluded category. The intercept shift for Zimbabwe is positive and statistically significant at less than 5 percent level of significance in all four sectors. In the case of Kenya, the intercept shift is smaller in magnitude than that for Zimbabwe in each of the sectors and statistically significant in only two of them. Clearly, therefore, the average levels of technical efficiency are lower in Ghana and Kenya relative to

[30] This is the methodology employed by Caves (1992) to compare US and Japanese manufacturing sectors. Needless to say, these intercept shifts would reflect a combination of not just firm-level factors but also those affecting firm efficiency at the industry and national levels too.

Zimbabwe while, in at least two of the sectors, firms in Kenya rank higher than those in Ghana. These results, therefore, are quite consistent with those in Table 3.4 above.

Table 3.5
Sectoral Stochastic Frontiers

	Food	*Textiles and Garments*	*Wood and Furniture*	*Metal*
Constant	3.02*	3.54*	4.25*	3.64*
	(.91)	(.69)	(.65)	(.56)
Log of Capital	0.53*	0.41*	0.30*	0.42*
	(.01)	(.07)	(.07)	(.07)
Log of Labor	0.51*	0.64*	0.81*	0.80*
	(.10)	(.13)	(.13)	(.12)
Capacity Utilization	0.43	0.41	0.50	0.38
	(.41)	(.39)	(.47)	(.35)
Ratio Manual to Total Labor	0.90	0.79	2.58*	0.41
	(.71)	(.88)	(.81)	(1.16)
Kenya	0.16	0.94*	0.64*	0.19
	(.21)	(.31)	(.21)	(.25)
Zimbabwe	0.85*	1.28*	1.13*	0.72*
	(.20)	(.36)	(.30)	(.24)
σ_u/σ_v	0.71	2.28*	2.38*	1.66**
	(1.60)	(1.09)	(1.17)	(.89)
$\mathrm{sqrt}(\sigma^2_u+\sigma^2_v)$	0.87*	1.23*	1.38*	1.08*
	(.38)	(.17)	(.19)	(.18)
ATE	0.67	0.46	0.42	0.51
Share of $\sigma^2(u)$	0.15	0.65	0.67	0.50

Note: Figures in parentheses are standard errors.
*Significant at 5 percent or less level of significance.
**Significant at 10 percent or less level of significance.

Source: RPED Survey Data from Zimbabwe, Kenya and Ghana, 1992-93.

There is considerable variation in Table 3.5 across the four sectors in terms of relative efficiency of firms within each. The proportion of total variation among firms attributable to technical inefficiency varies from a low of 0.15 percent in food processing to 50 percent in metal working to about 65 percent in the other two sectors. The low figure for the food processing sector reflects the low standard error of firm-level estimates of technical efficiency. Thus, while the efficiency levels of the most efficient firms are similar across all sectors, the lowest level of efficiency estimated in the food sector is only 0.44 while in the other three sectors it is less than 0.10 (the extreme values are not shown in the table above).

Average technical efficiency in the food sector is, consequently, the highest at 0.67 and significantly lower in the other three sectors. Note though that since the performance in each industry is examined relative to its own best practice frontier, the efficiency indices across the industries cannot be compared in terms of whether one industry is more efficient than another. We can, however, make rough international comparisons of the textiles and garments sector's average technical efficiency (0.47) in Africa with estimates for the same sector in other countries. Although differences in methodologies make direct comparisons difficult, it is worth noting that the mean efficiency for textiles and garments for the three countries seems significantly lower than similar figures estimated for Indonesia by Pitt and Lee (1981), equaling 0.68, and by Hill and Kalirajan (1993), equaling 0.63. Lee and Tyler (1978), similarly, report average technical efficiency of 0.63 for Brazilian industry while their estimate for Colombian apparel industry appears closer to the estimates for the three African economies at 0.55 (Tyler and Lee 1979).

We can also compare the estimated average technical efficiency of 0.42 for the wood and furniture sector above to the results obtained by Page (1980) for Ghana alone. Page (1980) estimated average indices of technical efficiency separately for logging, saw milling and furniture manufacturing, all of whom were significantly higher, ranging from 0.71 to 0.94. Given that Ghanaian firms in the present sample have lower levels of technical efficiency on average than those in Kenya and Zimbabwe, and that the estimate of 0.42 includes firms in all three countries, the average figures for Ghana alone in the present sample would obviously be very much lower than those estimated by Page (1980). Note, however, that the present estimates are relative to best practice frontier that incorporates firms in Kenya and Zimbabwe, which significantly lower the estimated efficiency of Ghanaian firms relative to that estimated with respect to a frontier specific to Ghanaian firms alone.

Inter-sectoral Comparisons of Relative Technical Efficiency

Comparison of inter-sectoral patterns in technical efficiency can be undertaken by estimating within-country frontiers assuming that the technology is common across industries although different in each country. Once again sectoral dummies are used to test the significance of intercept shifts across industries. The estimated cross-sector frontier regressions are presented in Table 3.6 below for each country.

Table 3.6
Within-country Stochastic Frontiers

	Ghana	*Kenya*	*Zimbabwe*
Constant	3.52*	4.34*	4.27*
	(.59)	(.65)	(.43)
Log of Capital	0.39*	0.37*	0.43*
	(.07)	(.07)	(.04)
Log of Labor	0.74*	0.77*	0.69*
	(.13)	(.12)	(.06)
Capacity Utilization	0.35	0.44	0.25
	(.36)	(.35)	(0.27)
Ratio Manual to Total Labor	0.79	0.91	3.19*
	(.89)	(1.06)	(.54)
Food	0.96*	0.31	0.33*
	(.33)	(.24)	(.15)
Wood and Furniture	0.25	-0.18	0.10
	(.28)	(.21)	(.18)
Metal	0.72*	0.15	0.15
	(.29)	(.26)	(.16)
σ_u/σ_v	1.92*	1.53	3.72*
	(.83)	(.98)	(1.79)
$\mathrm{sqrt}(\sigma^2_u+\sigma^2_v)$	1.37*	1.17*	1.11*
	(.18)	(.19)	(.10)
ATE	0.43	0.49	0.49
Share of $\sigma^2(u)$	0.57	0.46	0.83

Note: ATE = Average Technical Efficiency.
Figures in parentheses are standard errors.
*Significant at 5 percent or less level of significance.
**Significant at 10 percent or less level of significance.
Source: RPED Survey Data, 1992-93.

Again, average technical efficiency figures are not comparable across countries since they are estimated relative to best practice within the country. The proportion of total variance attributable to variance in the inefficiency terms is notably higher in Zimbabwe than in the other two countries. As before, this reflects higher variance in the firm-level estimates of technical efficiency. In terms of efficiency levels across the four sectors, the intercept shifts in Table 3.6 are relative to textiles and garments, the excluded sector. Clearly, though, there does not appear to be much sectoral variation in the technical efficiency of firms except for the food processing sector. None of the sector dummies are significant in Kenya and the metal working sector has a significant positive shift only in Ghana. The coefficients for the food-sector dummy are quantitatively largest in all three countries and statistically significant in Ghana and Zimbabwe. These results are consistent with the hypothesis that firms in the food-processing sector have relatively higher levels of technical efficiency on the average than firms in the other sectors. The results are also similar to those suggested by the frontier fitted to the full sample of firms in Table 3.3. In addition, there is some indication that firms in the metal working sector may be marginally more efficient on average although this finding is statistically significant only in Ghana.

In sum, therefore, the levels of average technical efficiency in the manufacturing sector of the three countries reveal a clear pattern that is consistent across different estimations. In each sector studied, firms in Zimbabwe show the highest levels of technical efficiency and those in Ghana the lowest. Rough comparisons suggest that the overall technical efficiency in the textiles and garments sector for these African countries is significantly less than that estimated for other industrializing countries in Asia and Latin America. Across sectors, on the other hand, not much variation appears in the data except for the food-processing sector which has unambiguously more efficient firms on average. Metal working firms are also marginally more efficient on average but this finding is not statistically significant in Kenya and Zimbabwe.

Efficiency Across Size Groups

Finally, we consider the distribution of average technical efficiency amongst firms in different size classes. Tables 3.7 and 3.8 below present estimated levels of average technical efficiency in firms in each industry and country arranged by different size classes. The estimates are based on the frontier regressions presented in Tables 3.5 and 3.6 respectively.

Table 3.7
Average Technical Efficiency of Firms by Size and Sector

	Food	*Textiles and Garments*	*Wood and Furniture*	*Metal*
<20[a]	0.68	0.44	0.42	0.49
20-49	0.66	0.47	0.41	0.47
50-99	0.68	0.43	0.48	0.56
100-199	0.67	0.53	0.42	0.54
200+	0.68	0.48	0.39	0.52

[a]Excluding firms with less than 3 employees.
Source: RPED Survey Data from Zimbabwe, Kenya and Ghana, 1992-93.

Table 3.8
Average Technical Efficiency of Firms by Size and Country

	Ghana	*Kenya*	*Zimbabwe*
<20[a]	0.44	0.48	0.51
20-49	0.39	0.53	0.42
50-99	0.48	0.55	0.44
100-199	0.50	0.49	0.50
200+	0.35	0.46	0.54

[a]Excluding firms with less than 3 employees.
Source: RPED Survey Data, 1992-93.

The figures in Table 3.7 show a pattern quite similar to that suggested by data on partial factor productivity in Tables 3.1 and 3.2. Again excluding the firms with less than 20 employees, we find that total factor productivity or technical efficiency has no significant relationship with firm size in the food sector. In the textiles and garment sector, on the other hand, firms in size class 100-199 clearly dominate all other firms. Similarly, in the other two sectors also, smaller firms in size class 20-49 employees display essentially the lowest levels of technical efficiency, which increases to its maximum for firms with 50 to 100 employees. In general, therefore, both sets of data are remarkably consistent, showing higher productivity in two sectors in the range of 50-199 employees and in the range of 100-199 workers in the textiles and garments sector.

A similar picture emerges when total factor productivity and firm size are evaluated across countries. As in Table 3.1, we again find that firms in the size class of 100-199 have the highest levels of technical efficiency in Ghana while in Kenya, on the other hand, the highest levels of average efficiency are shown by firms in the range of 50-99 workers. The only significant departure from the results in Table 3.1 is seen in case of Zimbabwe where the largest sized firms are the most efficient on average. In all other cases, both in terms of sectoral and national groupings, estimates of total factor productivity show medium-sized firms in the range of 50-99 workers or 100-199 workers as the most efficient on average.

Firm-level Determinants of Technical Efficiency

Given the wide variation in relative technical efficiency of the sampled firms, identification of factors that contribute to determining firm-level efficiency is an important policy issue. What makes one firm more efficient that another? As discussed earlier, there are a number of factors that impinge on the ability of firms to organize production efficiently and raise productivity over time. These include factors that operate at the national and industry or sectoral level as well as a number of skills and capabilities that are internal to the firm. A rigorous analysis of factors external to the firm, at the national or sectoral level, is not feasible from the firm-level data available to us. Consequently, in this section we focus on exploring firm-level sources of inefficiency in the manufacturing firms across all three countries surveyed. In particular, we are interested in evaluating the extent to which indicators of technological capabilities of firms (those presented in the case study chapters of Part II, for example) are significant determinants of firm-level efficiency.

While technological capabilities are, *a priori*, a critical input in the technical efficiency of enterprises, empirically this relationship is less well documented at the firm level. This is especially true in the context of Sub-Saharan economies where relevant evidence is particularly sparse. A major reason for this is the general paucity of empirical analyses of firm-level productivity in these countries.[31] However, there are some other important reasons why a strong relationship between firm-level technological capabilities and technical efficiency may not be found empirically. A potentially serious problem is the possible errors in measurement stemming from a poor fit between technological capabilities and the quantifiable indices used as indicators of such capabilities. For example, the simple existence of trained managers and engineers does not guarantee high firm specific productivity if individuals with formal credentials do not possess the production and engineering skills required to improve TFP.

In addition, factors external to the firm at the national or sectoral level may have productivity impacts mitigating firm-level factors, such that even accurately measured technological capabilities may not have a discernible effect on the observed technical efficiency of firms. For example, aspects of an industry's organization, such as vertical integration between manufacturers and retailers, may result in low productivity if, say, each firm finds it in its own strategic interest to produce a large range of products, thus foregoing the benefits of specialization. Alternatively, if there is limited rivalry, firms may view investment in cost reducing efforts as not worthwhile. Aside from industry level factors, the national economic environment established by macro and micro economic policies also impinges on the firm and may discourage or offset positive efforts at the firm level to increase productivity. Difficulty in obtaining raw materials and intermediate inputs of a given quality due to exchange controls, erratic supply of public services such as electricity, etc. are examples of factors that can have a direct impact on observed firm efficiency levels.

Our analysis of the firm-level relationship between technological capabilities and technical efficiency is constrained by the fact that these capabilities are not easily quantifiable. This applies especially to indicators of production and investment capabilities. Since these capabilities embody a number of qualitative aspects, the case studies for each country contain considerable details on a number of salient qualitative issues for a small number of firms. However, a comparable level of detail is not available from the large-scale survey instrument used for the full sample of firms.

A few indicators of levels of production capabilities in firms available for analysis are: education levels of the production manager and of the general manager, assignment of

[31] Two works relevant in this context are Page (1980) and Pack (1987).

personnel by the firm specifically for the task of productivity improvement, and whether or not the firm has scientists in its work force. In Table 3.9 below, we present results of mean-difference tests with respect to these four variables. The sample of firms is divided into two groups on the basis of each of these variables and the means of the groups are compared. Estimates of firm technical efficiency are derived using the stochastic frontier production functions presented in Tables 3.5 and 3.6 earlier.

The differences in means using these indicator variables are generally small in magnitude and insignificant. The presence of personnel assigned specifically to enhance productivity is associated with significantly higher mean efficiency for firms in Zimbabwe as is the education of the general manager or owner. In addition, with the exception of having personnel assigned for increasing productivity, all other indicators of production capabilities are associated with significantly higher mean efficiency for firms in the wood and furniture sector. Otherwise, all the differences in means in Table 3.9 are statistically insignificant.[32]

However, these results should not be viewed as showing that indicators of production and investment capabilities do not have a role in determining firm productivity. It is quite likely that the variables used as indicators are poor proxies for the actual production capabilities in the firms. For example, the variable denoting presence of personnel assigned to improving productivity is clearly related to firm size since such specialization of work is not found in small firms. At the same time, small firms nonetheless may also have workers (or the owner) carrying out similar productivity-related efforts. Regarding the role of education, it is important to differentiate between two types of effects. The first may be called the management effect: owning or managing a large firm, either through entry or expanding existing business, generally requires greater education. Thus, the average education of owners or managers for large firms in the sample is significantly higher than that for managers/owners of small firms. Secondly, education may also have a productivity effect: for a given size cohort of firms, greater education of the manager or owner may lead to greater efficiency in organization and production. The results in Table 3.9, (as well as further results in Table 3.10 later) suggest that the productivity effect of manager education is insignificant.

Statistical analysis of the effect of production and investment capabilities on firm technical efficiency will, thus, have to await better measurement of these technological capabilities. It should be noted though that where qualitatively rich data are available, as in the country case studies in the later chapters, the evidence is strongly suggestive of a significant role for such capabilities in determining firms' relative technical efficiency. [33] Biggs, Srivastava and Shah (1995) also provide some detailed examples of productivity increases in some exporting firms in Zimbabwe and the role of production and investment capabilities in that process.

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[32] Inclusion of these indicators in regression reported in Table 3.9 below always yielded insignificant coefficients.

[33] A good example is the case of the metal working firm with expatriate engineers in Ghana. See the country case study of Ghana in Chapter 7.

Table 3.9
Production Capabilities and Firm Efficiency

	Food		*Textiles and Garments*		*Wood and Furniture*		*Metal*		*Ghana*		*Kenya*		*Zimbabwe*	
	0	*1*	*0*	*1*	*0*	*1*	*0*	*1*	*0*	*1*	*0*	*1*	*0*	*1*
Have Productivity Personnel	0.67	0.69	0.42	0.46	0.42	0.47	0.51	0.53	0.43	0.45	0.48	0.54	0.48	0.55*
High Education of Production Manager	0.68	0.66	0.45	0.49	0.39	0.49*	0.50	0.53	0.41	0.47	0.49	0.49	0.48	0.51
High Education of General Manager	0.67	0.67	0.45	0.49	0.41	0.49*	0.50	0.52	0.44	0.41	0.49	0.51	0.47	0.53*
Have Scientists	0.67	0.68	0.47	0.45	0.41	0.52*	0.51	0.51	0.43	0.41	0.48	0.52	0.49	0.54

Note: The dummy variable equals one if the firm possesses the specific indicator, zero otherwise.
* Significant at the 5 percent or less level of significance.

Source: RPED Survey Data, 1992-93.

In contrast to investment and production capabilities, the data on indicators of learning mechanisms available to firms are much more clearly defined. Learning mechanisms constitute the dynamic element of the three types of technological capabilities, enabling firms to change over time the levels of investment and production capabilities. The specific types of learning mechanisms and human capital augmenting variables available for the full sample of firms are as follows: training of workers within and outside the firm, technology transfer from abroad through technical assistance contracts or licensing arrangements, foreign ownership and exports. Amongst these, training constitutes an internal learning mechanism for augmenting human capital within the firm, while all the other (foreign-linkage) variables can be viewed as conduits for the flow of knowledge and skills into firms from outside the country. In addition to direct technology transfer through licensing and/or technical assistance, firms can also acquire technical expertise (as well as embodied technical change) in the process of direct foreign investment into the firm. [34] Moreover, as discussed in the previous chapter, interaction with foreign buyers in the process of exporting often leads to technical improvement in the host country firms.

Since preliminary mean-difference tests are significant (not reported), we explore further the contribution of these learning variables to firm efficiency using an augmented production function of the Cobb-Douglas type as before. Specifically, if technical skills in the firm enhance its productivity, the value added Y can be written as being determined by

$$Y=AK^{\alpha}L^{\beta}T^{\delta}$$

where T is an index of a firm's technical skill level. Assuming T depends on a vector X of firm-specific variables indicating learning mechanisms and takes the form $T= e^{\lambda X}$, the logarithm of Y can be written as

$$\ln Y = \ln A + \alpha \ln K + \beta \ln L + \delta^{*} X + \varepsilon$$

where $\delta^{*}=\delta\lambda$ and ε is an error term. Estimates of δ^{*} provide information on whether the variables in X are correlated with value added, holding labor and capital fixed. However, several issues arise in interpreting the estimated coefficients. Firstly, while all policy induced effects on firms' value added are assumed to be subsumed in A in the equation above, it is quite possible that these effects have differential impacts across firms. The coefficients of the variables X will then be incorporating these differential effects which cannot be disentangled without a greater level of disaggregation than feasible in our sample. Secondly, omitted variables bias may be a problem if unmeasured determinants of value added (e.g., entrepreneurial skill of owner) are correlated with the variables included in X (e.g., access to finance). Finally, the single-equation formulation may lead to simultaneity bias in the estimated coefficients if any variables in X are determined jointly with value added. For example, to the extent training requires investment by the firm, its level may be determined

[34] See Pitt and Lee (1981) for an analysis of the role of foreign ownership in determining firm efficiency in the Indonesian garment industry.

jointly with value added by the firm.[35] Given the cross-sectional data available, there are no obvious solutions to these problems but structural interpretation of this reduced-form relationship should be avoided.

The specific definitions of the additional variables included in X above are as follows:

Training:	Percent of work force in the firm participating in internal or external training. The training may be formal or informal, although in an overwhelming majority of the firms, there is only informal training, (see Chapter 3).
Export:	Dummy variable, 1 if the firm exported in the year of the survey, 0 otherwise.
Technology transfer:	Dummy variable, 1 if the firm has a technical assistance contract or a licensing arrangement, 0 otherwise.
Share of foreign ownership:	Percentage of equity holding held by foreign investors.

All these learning-related variables are expected to contribute to greater productivity in the firms. In addition to these learning variables, we also incorporate in our analysis the role of finance in effecting firm-level efficiency. Policy makers and analysts alike focus on the critical importance of finance to firms, particularly in developing economies. Consequently, we include a dummy variable denoting *access to external working capital* which equals 1 if the firm has overdraft facilities from banks or (trade) credit facilities from its principal suppliers; otherwise its value is 0. Finally, we also include years of education of the general manager or owner of the firm and firm age. Inclusion of firm age seeks to take into account possible vintage effects, such as the ability of younger firms to utilize more recent and advanced technology.

An issue worth noting in the context of learning variables stems from the distinction between stock of human capital in the firm and the flow of services from this capital. For example, the contemporaneous impact on value added of investment in human capital through worker training or technology transfer may be minimal, taking effect only over time. However, if we assume that firms investing in human capital now have also been doing so in the previous years, then contemporaneous indices of learning variables can denote firms with high stocks of human capital relative to those firms not investing in augmenting human capital.

[35] However, elsewhere we have shown that endogenizing firm's decision to invest in training or in technology transfer leads to results quite similar to the OLS results presented below. See Biggs, Shah and Srivastava (1995).

The production function is estimated using ordinary least squares corrected for heteroscedasticity in errors. The results are presented in Table 3.10 for the full sample of firms and by country. A high proportion of the total variance in value added is explained in each of the regressions. The two quality related variables - skilled labor ratio and capacity utilization rate - are significant for the sample as a whole but not in either Kenya or Ghana. Firm age has a positive sign in all cases, indicating greater productivity of older firms, but is insignificant in Ghana and Zimbabwe. The intercept shifts for sector dummies show results similar to those obtained by maximum likelihood estimates of stochastic frontier production functions earlier. Thus, firms in the food sector have an unambiguously higher and significant intercept shift while those in the metal sector have a smaller, positive intercept shift which is insignificant in case of Kenya and Zimbabwe. Similarly, the country dummies in the overall sample show the largest intercept shift for firms in Zimbabwe, followed by the shift for firms in Kenya; both coefficients are significant at 5 percent level of significance. These results are also similar to those discussed earlier in the analysis.

As might be expected from Table 3.9 earlier, the coefficient for education of the general manager/owner is insignificant in all cases. However, with the exception of the export dummy, all learning variables have a positive impact on productivity that is statistically significant at the 5 percent level for the full sample. Quantitatively, worker training has the largest impact for the whole sample as well as in each country except Kenya. Thus, for the sample as a whole, if the percent of total workers being trained by firms is increased by 1 percent from its sample average of 9 percent, value added would increase by almost 60 percent. The impact of both foreign ownership and technology transfer is the highest in Ghana, exceeding 60 percent, but for the sample as whole (as well as in Zimbabwe), these variables increase value added in firms by about 30 percent. All learning variables are statistically significant in both Ghana and Zimbabwe while the regression for Kenya shows none of these variables as significant. This is somewhat surprising and suggests the possibility of greater noise in the Kenyan data relative to the other two countries. The only additional variable significant in Kenya is access to finance for working capital. Indeed, access to finance has a coefficient that is relatively large compared to all the learning variables and is significant across each country in the sample. For the sample as whole, financial access to working capital increases value added by 40 percent.[36] This is an interesting finding with important policy implications since financial constraints are often perceived as significant determinants of firm performance and growth.

[36] The firms' revealed access to longer-term bank loans was also used as an indicator of access to finance. However, it consistently yielded small, negative and insignificant coefficient. This would suggest that bank loans are used by firms mostly for fixed-asset acquisition and do not directly affect the ability of the firms to utilize these assets efficiently.

Table 3.10
Sources of Efficiency in Manufacturing Enterprises

	Full Sample	*Ghana*	*Kenya*	*Zimbabwe*
Constant	2.71*	2.48*	3.44*	3.23*
	(.34)	(.65)	(.62)	(.50)
LogCapital	.37*	.41*	.27*	.38*
	(.04)	(.06)	(.07)	(.06)
LogLabor	.65*	.58*	.77*	.63*
	(.06)	(.12)	(.11)	(.09)
Ratio of Skilled Workers	1.2*	-.13	1.5	2.6*
	(.47)	(.73)	(1.0)	(.88)
Capacity utilization	.51*	.39	.41	.67*
	(.19)	(.45)	(.29)	(.26)
Log Firm Age	.10**	.10	.24*	.08
	(.06)	(.09)	(.12)	(.07)
Food	.45*	.82*	.27	.26**
	(.12)	(.29)	(.21)	(.15)
Wood and Furniture	-.02	.26	-.31	.14
	(.13)	(.28)	(.23)	(.20)
Metal	.28*	.53**	-.14	.12
	(.13)	(.29)	(.21)	(.76)
Kenya	.37*	-	-	-
	(.12)			
Zimbabwe	.84*	-	-	-
	(.12)			
Export dummy	-.05	-.24	.13	-.11
	(.10)	(.32)	(.18)	(.89)
Technology Transfer	.30*	.78*	.03	.38*
	(.11)	(.31)	(.17)	(.14)
Worker training	.65*	2.2*	-.28	.56*
	(.29)	(.69)	(.74)	(.28)
Share of Foreign	.27*	.63**	.08	.32**
Ownership	(.14)	(.36)	(.22)	(.19)
Education General	.07	-.18	.19	.13
Manager	(.09)	(.22)	(.16)	(.11)
External Working Capital	.40*	.27**	.63*	.51**
	(.13)	(.17)	(.27)	(.28)
Adjusted R^2	0.89	0.82	0.86	0.91

Note: Figures in parentheses are standard errors.
*Significant at 5 percent or less level of significance.
**Significant at 10 percent or less level of significance.

Source: RPED Survey Data, 1992-93.

Another interesting but puzzling result in all these regressions relates to the performance of the export dummy which is not only insignificant but also negative in all cases except Kenya. This result is in stark contrast to findings for Asian countries where exporting has been found to be associated with significantly higher levels of firm productivity. The negative relation of exports to firm productivity is quite robust in our sample of firms and is an anomaly that we intend to investigate in later research.[37]

We can summarize our findings by noting that the learning-related technological capabilities that enhance firms capacity to build and augment human capital have an unambiguously positive impact on productivity. In particular, we are able to explore the role of worker training and of foreign-linkage variables such as foreign investment, technology transfer in the form of technical assistance contracts and foreign licensing, and export activity. With the exception of exports, all indicators of learning mechanisms are quantitatively important determinants of productivity in firms. In addition, access to finance for working capital is also seen to be important in determining firm performance in all three countries. At the same time, statistical analysis of the relationship between investment and production capabilities and firm efficiency is not feasible given the absence of reliable measures of such capabilities in the large sample. However, qualitative details in case studies indicate that these capabilities play an important role in affecting firm performance.

Technical Efficiency of Microenterprises and Small Firms

Small and micro-enterprises (SMEs) constitute a major proportion of all firms in Sub-Saharan economies. They also often occupy a center stage in policy discussions related to employment creation and poverty alleviation. Consequently, in this section we focus exclusively on productivity analysis for this size cohort of firms in the sample. In addition, since all these firms are entrepreneur owned, focusing on this group also allows an evaluation of the extent to which *personal* attributes of owners significantly influence firm productivity.

In principle, there is no theoretical reason why firms of a particular size should be viewed as fundamentally different to other firms. It is for that reason that the estimation of sectoral and national stochastic frontier production functions in the earlier sections included SMEs as well as other firms. As seen in Tables 3.7 and 3.8, estimates of average technical efficiency of SMEs relative to the full sample of firms are generally comparable in magnitude to those of firms in other size classes. At the same time, however, estimation of levels of technical efficiency in SMEs relative to larger firms is complicated by the possibility of greater noise in their data relative to those of the latter firms.[38] In particular, if the reported

[37] For example, one may have to differentiate between firms exporting to industrially more advanced countries as distinct from those exporting to neighboring African economies. Alternatively, in protected markets with scarce foreign exchange, firms may export even at a loss to acquire needed foreign exchange.

[38] Thus, many SMEs do not keep annual accounts thereby entailing data collection on a monthly or weekly basis. If the shorter period is not "representative", temporary shocks to revenues or costs are substantially magnified when annualized. Furthermore, sometimes these firms do not have good records for inputs and outputs even for smaller periods of accounting.

use of labor by SMEs fails to incorporate fully use of family labor, the estimated figures on their technical efficiency will be biased upwards. If the biases from measurement errors are similar across various SMEs, it is possible to estimate a best practice frontier for these enterprises alone. Although not useful in evaluating levels of technical efficiency in SMEs relative to other firms in the economy, these estimates enable us to investigate patterns in the distribution of relative technical efficiency of SMEs across the three countries. I.e., within the size class of small and micro-enterprise firms, are firms in one country significantly more efficient than those in another? In Table 3.11 below, we present such estimates of average technical efficiency from a stochastic frontier production function fitted only to the sample of SMEs, defined as all firms with 3-20 employees, and assuming identical technology across different sectors with the exception of intercept shifts (i.e., sector dummy variables).

Table 3.11
Average Technical Efficiency of SMEs

	Average Efficiency	*Standard Deviation*	*Minimum*	*Maximum*
Ghana	0.34	0.20	0.02	0.76
Kenya	0.34	0.21	0.03	0.78
Zimbabwe	0.50	0.19	0.10	0.75
Full Sample	0.38	0.21	0.02	0.78

Source: RPED Survey Data, 1992-93.

Results for the sample of SMEs alone are, in general, consistent with those obtained earlier for the full sample of firms. Clearly, SMEs in Zimbabwe display significantly higher levels of technical efficiency on average than those in either of the other countries. However, in contrast to the earlier findings, there is no significant difference between relative technical efficiency of SMEs in Kenya versus Ghana. The dispersion in technical efficiency of firms is quite similar in all three countries; in addition, as before, the levels of efficiency in the most technically efficient SMEs are similar across countries while those for the relatively inefficient firms vary significantly, being much lower in Ghana and Kenya.

In terms of the determinants of technical efficiency in SMEs, we again estimate an augmented Cobb-Douglas production function. In addition to the variables used in the specification for the full sample of firms, we now also include five additional variables reflecting personal attributes of the owner. Key variables of interest here include variables capturing entrepreneurial human capital, family and network linkages, and access to finance. The specific variables we include are as follows:

Fambus: Is a dummy variable equaling 1 if either parent of the entrepreneur (usually father) also had a manufacturing or trading business. In terms of learning potentially useful skills as well as having access to pre-existing network of business contacts, this variable may contribute to greater productivity in the firm *ceteris paribus*.

Bornhere: Is a dummy variable equaling 1 if the entrepreneur was born in the town where the business is located, 0 if he or she is a migrant. As in the previous variable, local status can be viewed as an indicator of possible access to network capital for the entrepreneur. On the other hand, there may be a positive migrant effect: migrants may be argued as more likely to perform better than locals.

Formal: Is a dummy variable equaling 1 if the SME is formally registered as a business, 0 otherwise. This variable allows a first cut at differentiating between formal and informal sector firms among the SMEs in the sample.

Lexperience: Is the log of years of entrepreneur's experience in business *prior* to establishing the current one.

Diverse: Is a dummy variable equaling 1 if the entrepreneur owns more than 1 business. This variable can be interpreted as denoting entrepreneurs who are more skilled than others or as another indicator of access to finance on part of the entrepreneur. As long as the revenue streams of the different businesses are not perfectly correlated, an entrepreneur with more than one business has greater access to funds for liquidity management and working capital. Alternatively, the variable can be interpreted as a proxy for entrepreneur wealth which again is correlated with superior access to financial capital.[39]

Given the small employment size of the SME firms, even if 1 or 2 workers in the firm are being trained, the percent figures can be extremely high. Consequently, in contrast to the earlier specification, *worker training* now is a dummy variable rather than the percentage of workers being trained in the firm. Finally, *Highedd* is a dummy variable equaling 1 if the owner of the firm has more than secondary education (either university or polytechnic), and 0 otherwise.

[39] Our broad specification estimated does not allow for differentiation between the alternative interpretations but such distinctions are not of immediate interest to our present objectives. Such issues will be pursued in greater detail elsewhere in related components of the ongoing RPED research program.

Table 3.12 below summarizes the OLS estimates of the augmented production function.

Table 3.12
Determinants of SME Efficiency

Variable	*Coefficient*
Constant	2.73*
	(.66)
Log capital	0.31*
	(.07)
Log labor	0.65*
	(.19)
Ratio of skilled workers	0.47
	(.71)
Capacity utilization	0.79**
	(.42)
Working capital	0.37*
	(.18)
Diverse	0.32**
	(.16)
Fambus	-0.16
	(.26)
Bornhere	-0.24
	(.21)
Formal	0.42*
	(.18)
Highedd	-0.05
	(.16)
Lage	0.31*
	(.13)
Lexperience	0.22
	(.15)
Lage*Lexperience	-0.11**
	(.06)
Worker training	0.99*
	(.30)
Kenya	0.07
	(.21)
Zimbabwe	0.96*
	(.21)
Food	0.53*
	(.24)
Wood and Furniture	-0.03
	(.26)
Metal	0.25
	(.27)
Adjusted R^2	0.68

Note: Figures in parentheses are standard errors.
*Significant at 5 percent or less level of significance.
**Significant at 10 percent or less level of significance.

The estimated equation is corrected for heteroscedastic errors and explains a reasonably high proportion of the total variance in value added. Both labor and capital are significant and the null hypothesis that their coefficients sum to 1 yields an insignificant F-statistic, namely, $F(1,116) = 0.10$. The adjustment for labor quality is insignificant which may reflect the fact that these firms represent mostly low-skill activities. The coefficient for capital utilization, however, is significant at the 10 percent level of significance. Furthermore, the country dummy variables show the expected results with the intercept shift for Zimbabwe large and significant at 5 percent level of significance while that for Kenya quantitatively and statistically insignificant. Across sectors, the results are similar to those in Table 3.10 for the full sample: the dummy for food sector has a large coefficient that is highly significant while that for metal is positive but insignificant and that for the wood sector is not even quantitatively significant. The significant intercept shift for the food sector reflects the low dispersion in relative technical efficiency seen earlier for the full sample.

The other explanatory variables in the regression are highly significant and provide an interesting picture. Firstly, finance again proves to be an important variable in determining firm productivity. Thus, access to working capital and ownership of more than one business by the entrepreneur both have relatively large coefficients, implying an impact on value added exceeding 30 percent in each case, and are each significant at the 5 percent level of significance.[40] Secondly, as before, worker training shows a large and statistically significant impact on value added. Thus, even in the relatively low-skill firms and activities, learning mechanisms like training can have a high impact. Indeed, the impact of worker training on value added of SMEs, equaling 99 percent, is larger than that for the sample of all firms taken together. Thirdly, productivity in SMEs is positively related to both the age of the firm as well as the business experience of the entrepreneur prior to starting up the firm. Although the coefficient of entrepreneurial experience is not statistically significant, those for firm age and the interaction of the two variable are both significant. The negative sign of the coefficient for the interaction term shows that firm age and entrepreneur's prior experience are substitutes for one another. Thus, the impact of firm age on value added is positive but, the greater the prior experience of the entrepreneur, the smaller this impact. Similarly, the impact of entrepreneur's prior experience on firm's value added is positive, but its magnitude is negatively related to the age of the firm.

Both the network and migrant-effect variables are insignificant, adding nothing to the explanatory power of the regression. Thus, family business has the wrong sign while the coefficient for Bornhere suggests that migrant entrepreneur perform better, but this result is also statistically insignificant. The same results apply to entrepreneur's education level whose coefficient shows a wrong sign but is also almost completely insignificant.

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[40] For SMEs, as with the full sample of firms, the important financial variables *vis-à-vis* operating efficiency are working-capital related: thus, bank loans proved insignificant in explaining variations in value added across these firms.

Finally, another interesting finding shown by these results is that even within the SMEs, firms in the formal sector, in the sense of being formally registered, are unambiguously associated with greater value added relative to unregistered, informal firms. The coefficient for the dummy variable denoting formal/informal status of the SMEs is quantitatively and statistically highly significant. Needless to say, the framework utilized in Table 3.12 does not enable us to determine the implicit causality in this association. On the one hand, it is possible that firms that are registered have access to better infrastructure and thus can increase productivity while, on the other hand, it is also possible that the relatively more efficient SMEs over time get registered and move into the formal sector; or, alternatively, that entering the formal sector entails "investing" resources (e.g., by regularly paying taxes, acquiring a fixed site, etc.) and that not becoming registered is a reflection of financial weakness which is also associated with lower value added. Differentiating between alternative mechanisms that can explain productivity differentials among formal and informal SMEs is beyond the immediate scope of our present objectives and will therefore be pursued elsewhere.

Summary of Findings

Manufacturing productivity is a critical determinant of the ability of domestic firms in Sub-Saharan economies to survive and grow as they face increasing exposure to external competition. Furthermore, sustained increase in levels of firm productivity is also an important policy objective associated with long-run growth of the type seen in newly industrialized Asian economies. However, very little evidence exists on productivity levels in Sub-Saharan African manufacturing. The data collected by RPED surveys therefore fill a large gap in the study of these economies. Our analysis of manufacturing productivity based on the RPED data provides a number of findings that are important for formulating policies to increase growth in Sub-Saharan countries.

Comparison with Asian economies using data on factor intensities and partial factor productivities clearly suggests that African manufacturing displays a similar structure as found in other developing regions. Thus, for firms with more than 20 employees, there is no presumption that smaller firms are more labor intensive than large firms in either the Asian countries or in the three Sub-Saharan African countries. In addition, the African firms display the same relationships between factor intensities and partial productivities as are seen in case of the Asian countries. At the same time, in contrast to the Asian firms, the African firms surveyed show a clear structural dualism with a significant break in factor intensities between the very small firms and others: firms with less than 20 employees are clearly more labor intensive than all other firms.

There is considerable heterogeneity in the average technical efficiency of firms across the three African countries. Estimates of relative technical efficiency show that firms in Zimbabwe are significantly more efficient than firms in either Kenya or Ghana, while there is also some evidence that firms in Ghana are on average less efficient than those in Kenya if all sectors are considered together. The clear dominance of Zimbabwean firms is unaffected when the sectors are considered separately: in each sector, firms in Zimbabwe are more efficient than those in the other two countries. In two of the sectors, namely textiles/garments and wood/furniture, firms in Kenya also show significantly higher value added than those in Ghana. Clearly, therefore, Ghanaian firms tend to be the least efficient on the average in this sample.

In contrast, inter-sectoral variations in relative technical efficiency are relatively insignificant in all the three countries. With the exception of firms in the food processing sector, which tend to show relatively little dispersion in estimated efficiency across different firm sizes, the remaining three sectors appear broadly comparable in terms of total factor productivity. Only in Ghana, firms in metal working show greater efficiency on average than firms in either textile/garment or wood/furniture sectors. Although direct comparisons are not feasible, estimates by other studies of technical efficiency in the textile/garment sector in Latin American economies show higher levels of average efficiency than seen in firms in the three African countries. Most firms in these African countries are poor performers even in comparison to domestic best-practice firms. If the reference best-practice frontier included more industrialized countries, the relative technical efficiency of African firms would appear even lower.[41]

Amongst firms with at least 20 employees, our results show that firm efficiency increases with firm size up to a point before declining for the largest sized firms. This relationship holds in all sectors except food processing where there is no relationship of firm efficiency to firm size. Firms with 100-199 workers are the most efficient in textiles and garment sector while in the other two sectors the most efficient firms on average are those with 50-99 employees. Thus, medium sized firms tend to be the most efficient on average in the sample.

The analysis of sources of inefficiency in the sampled firms yields additional important findings. In particular, the results show that *all* learning mechanisms that firms can use to change their endowments of production and investment capabilities have a large impact on enhancing productivity. On the job training of workers, both inside and outside the firm, has relatively the largest impact on value added by firms; an increase of 1 percent in the number of workers trained in this sample of firms could increase the value added by 60 percent. Similarly, informational links established by foreign direct investment contribute to an increase in value added by 30 percent, an impact comparable to that obtained by technology transfer through technical assistance contracts or licensing arrangements. Interestingly, our results also show that access to working capital financing is another critical determinant of firm efficiency. For the sample of firms as a whole, access to such financing increased value added by 37 percent.

[41] For example, one of the more efficient firms in Ghana is a multinational food processing corporation with branches in almost every country of the world. A recent study by the parent found the Ghanaian subsidiary to be the least technically efficient amongst all its subsidiary branches. See the country case study for Ghana in Chapter 7.

A similar picture emerges when we consider only the very small firms and microenterprises. Again training of workers is the most important contributor to higher value added by firms while access to working capital finance has an impact coefficient of 40 percent. In addition, previous experience of the entrepreneur and age of the firm, both of which contribute to human capital in the firm, are also positively associated with value added. They tend, however, to be substitutes: the older the firm, the lower the impact of owner's previous experience and, conversely, the impact of firm age is less for entrepreneurs that have greater amount of previous business experience. Our results also show that even within the very small firms, firms that are in the formal sector in the sense of being registered entities have substantially higher levels of value added than the small informal firms. Finally, differences in relative technical efficiency are also seen across countries. Small firms and microenterprises in Zimbabwe have significantly higher levels of value added while the difference between such enterprises in Ghana and Kenya is not statistically significant.

Part II:
The Case Studies

4. Technological Capabilities And Learning Mechanisms: Synthesis and Cross-country Comparison

The existence of large inter-firm productivity differentials, across the three countries as well as within sectors in each country, reiterate the proposition that firms differ in their abilities to acquire, utilize and innovate technologies. The empirical analysis in the previous chapter has highlighted the extent to which such systematic deviations from best-practice frontiers can be attributed to various types of skills and capabilities firms bring to bear in organizing production activities. These elements of firms' capabilities were discussed in Chapter 2 as grouped under three broad headings: physical investment and investment capabilities, production capabilities, and learning mechanisms. Physical investment, representing capital-embodied technical change, and investment capabilities that determine the efficiency of such investment are the most "basic" technological requirements, necessary for industry to exist and to thrive competitively. Production capabilities are the skills and knowledge needed to operate and improve the plant to achieve competitive levels of cost and quality. Human capital, in terms of the skills generated by formal education, and also those created by on-the-job training and experience of production and technological activity, is the critical input in determining the efficiency with which capital investments are utilized and production is carried out. Both labor and physical capital are only fully productive when technical learning efforts are made by enterprises to assimilate and improve upon the relevant technology.

Since not all components of firms' technological capabilities are easily quantifiable, in Part II of this report, we attempt to provide greater qualitative details on such capabilities in firms in the three Sub-Saharan African economies. Needless to say, systematic empirical evidence on the levels of technological capabilities in these economies, like many other data relevant to them, is also extremely limited. Consequently, the focus in this part of the report is to provide a detailed "snapshot" of the endowments of various technological capabilities in each country. In practice of course, the measurement and interpretation of technological capability variables across countries are fraught with difficulties. Not all education or training is of the same quality, not all technical effort is equally efficiently made, and no measure captures fully the routine engineering work devoted to adaptation of machinery or its mastery. The data we have gathered from firms in each country are often proxies for the true unobservable variables. They are in many ways impressionistic data, which nevertheless provide a substantive impression of the capability endowments of each country and of the national abilities to "transform" these endowments via the strength of the learning channels available.

The data utilized in Part II of the study were obtained from two primary surveys conducted in each of three countries in Sub-Saharan Africa: Ghana, Kenya and Zimbabwe. The first survey utilized a large-scale survey questionnaire covering a comprehensive set of issues related to the firms' activities in product markets, labor markets and financial markets, as well as aspects related to general firm characteristics, entrepreneurial attributes, infrastructure, regulation and technological capabilities. The survey instrument was essentially identical in all three countries and was applied to a number of randomly chosen firms: 164 firms in Ghana, 224 in Kenya and 200 in Zimbabwe. These surveys, denoted as RPED surveys, were conducted in 1992 in Ghana and in 1993 in the other two countries.[42] A sub-sample of firms from the RPED survey in each country was then chosen by a subsequent survey focusing exclusively on issues related to technological capabilities. These case studies surveyed 32 firms in Ghana, 35 in Kenya and 41 in Zimbabwe. The results of the case studies are presented separately as country studies in the subsequent three chapters of Part II. Each chapter also provides further details on the data collection efforts in that country, including sample design and comparisons of the RPED survey and the case study samples in terms of basic firm attributes.

The objective of this chapter is to provide a synthesis and summary evaluation of technological capabilities in each country surveyed. In addition to presenting the main findings of interest in each country, the analysis here seeks to compare the levels of technological capabilities and the scope of learning mechanisms, both private and collective, between the three countries as well as provide an international context when possible. The first part of the chapter discusses relative technological capability endowments in terms of investment and production capabilities in Ghana, Kenya and Zimbabwe, while the second part is devoted to a comparative analysis of learning mechanisms in the three countries.

A review of the basic aggregate economic data for Zimbabwe, Kenya and Ghana indicates some distinct inter-country differences, particularly in manufacturing (Table 4.1). The share of manufacturing in GDP in Zimbabwe is more than twice that of Kenya and Ghana. As noted in the country studies, this difference in the relative size of manufacturing is due in large part to the heavy-handed import substitution policies of Zimbabwe's UDI[43] period in the 1960s and 1970s. Zimbabwe's manufactured exports are also the largest in Sub-Saharan Africa. It has about twice the manufactured share of Kenya and many times that of Ghana, which has an exceedingly small share of manufactures in exports for its level of per capita income. Given such distinct differences in manufacturing activity as well as the results in the previous chapter indicating the higher rankings in average technical efficiency of firms in Zimbabwe followed by Kenya relative to Ghana, one might expect to observe significant differences in enterprise technological capabilities among the three countries. Zimbabwe, on average, would be expected to have larger endowments of physical and human capital, and more extensive learning mechanisms. Ghana, on the other hand, would be predicted to have the lowest capability endowments and consequently the lowest average enterprise technical efficiency. As the following discussion documents, these expected outcomes are borne out to a large extent by the data collected in the RPED case studies.

[42] Note that the analysis in Chapter 3 utilized data from this large-scale survey. The RPED surveys have subsequently been undertaken for the same firms twice more, with a gap of one year between each round. Results from the later rounds will be analyzed when they come in, and are not included in the analysis presented in this study.
[43] Unilateral Declaration of Independence in 1963.

Table 4.1
Basic Economic Data Comparisons — Zimbabwe, Kenya and Ghana

	Zimbabwe	*Kenya*	*Ghana*
GDP/Population, 1992 (US$ millions)	580	330	460
Population (millions)	10.4	24.7	15.8
MVA/GDP, 1991	26%	12%	10%
Manuf. Exports/Total Merchandise Exports	38%	22%	1%

Source: World Bank, 1993. *World Development Report: World Development Indicators.* New York: Oxford University Press.

Investment and Investment Capabilities

Investment

As a source of capital-embodied technical change, investment in physical capital constitutes an important element of firms' technological efforts. The advent of structural adjustment programs in Zimbabwe, Kenya and Ghana has had a positive effect, though modest, on private manufacturing investment. A significant number of firms in each country report making major additions to or changes in plant and equipment in the 1990-92 period. Investment activity, however, has been uneven across the countries. The investment response in Zimbabwe, on average, appears more vigorous; a higher proportion of enterprises are making major changes in plant and equipment and spending more money (Tables 4.2 and 4.3). Ghana, on the other hand generally lags behind in terms of both the proportion of firms investing and magnitudes of these investments. Why Ghana brings up the rear is curious. Conventional wisdom would have it that Ghana is lagging because the structure of investment incentives is stifling investment demand. But, in terms of Ghana's overall macropolicy stance, it has been ranked much higher than the other two (see World Bank 1994a, pg. 58, for an overall macropolicy ranking). This fact makes one turn attention to the possibility that supply side factors, such as access to finance and technological capabilities, may be playing a more significant role in these investment differences than previously recognized.

Sectoral variation in investments across the countries does not appear extreme. In Zimbabwe, more resources are being invested in the textiles/garments and wood sectors; in Kenya, in food processing and metal working; and in Ghana, in wood working and metal working, but the differences are not great. Given the basic resource endowments of each of these countries, investment patterns indicated in Tables 4.2 and 4.3 follow predicted flows. In addition, the stated purpose of investments in the RPED surveys shows no significant differences across the countries. Firms in each of the countries are trying to add to capacity in those sectors where economic activity is expanding, and trying to improve production processes to reduce costs and raise product quality to compete with imports or expand exports.[44] Very few investments are aimed at bringing new products to the market in these countries.

Table 4.2
Enterprise Investment by Size Class in Zimbabwe, Kenya and Ghana, 1990-92

	Investment/Capital Stock[a] *(Mean Value — Percent)*			*Proportion of Firms Investing*		
Firm Size (No. of Employees)	*Zimbabwe*	*Kenya*	*Ghana*	*Zimbabwe*	*Kenya*	*Ghana*
<10	20	12	10	83	67	36
10-49	14	10	15	81	78	55
50-99	14	7	2	78	92	33
100-249	17	9	6	90	96	58
250+	16			91		

[a]Ratios include non-investing firms in the sample. Capital stock = Replacement Cost of Capital.
Source: RPED Survey Data, 1992-93.

Table 4.3
Enterprise Investment by Sector in Zimbabwe, Kenya and Ghana, 1990-92

	Investment/Capital Stock[a] *(Mean Value — Percent)*			*Proportion of Firms Investing*		
Sector	*Zimbabwe*	*Kenya*	*Ghana*	*Zimbabwe*	*Kenya*	*Ghana*
Food	15	12	5	83	78	43
Textile/Garments	19	10	6	82	76	32
Wood	18	8	5	90	83	47
Metal	10	11	11	83	80	61

[a]Ratios include non-investing firms in the sample. Capital stock = Replacement Cost of Capital.
Source: RPED Survey Data, 1992-93.

Investment Capabilities

The outcome of a firm's investment efforts depends critically on its investment capabilities; the impact for the country as a whole will be derived from the aggregated capabilities of its individual enterprises. Investment capabilities, as noted earlier, are the skills and information needed to identify feasible investment projects, locate and purchase suitable technologies, design and engineer the plant, and manage the construction,

[44] Data on purpose of investment are provided in country studies in the Annex.

commission and start-up. In what follows, we evaluate these capabilities in terms of firms' responses to survey questions regarding initial acquisition of technology: how, at inception, was the investment project (i.e., the firm/plant) evaluated; how was the technology selected and appropriate machinery identified; how was the equipment installed; and, how were technical problems at start-up solved?

Our findings from the surveys indicate that inter-country variability in investment capabilities *within a given industry* is determined largely by heterogeneity in firm size and ownership. Five categories of enterprises, based on these two variables, can be distinguished in each of the countries, each with a distinct set of characteristics and technological capabilities. Variability in national capabilities will be due partly to the differing mix of each category of enterprise within the local economy.

The first distinct category of enterprise is the multinational corporation (MNC), with its connections to world market technical hardware and knowledge via the international headquarters of the parent company. Local subsidiaries of MNCs inevitably rely on their parent companies for all aspects of investment, ranging from the choice of equipment to the designing, procuring, setting up and commissioning of the plant. However, there is usually little transference of such technical information to local personnel. For example, three MNC subsidiaries in food processing in Ghana, which have been in existence for almost 40 years, were planning or had recently set up new investments at the time of the surveys, but *all* technical investment functions of these projects were still being handled by the respective parent companies.[45]

The second category comprises the medium to large, well-established, local companies, which are owned by the local "expatriate" community — Asians, Lebanese, Europeans and the like. They often operate like multinationals in that they have connections to other companies and technologies abroad, usually by way of family connections and other informal networks. Third, is the modern, well-managed indigenous medium to large company, which is beginning to emerge in these countries in the wake of structural adjustment. Often these firms lack appropriate connections to international markets for technological knowledge and therefore must deal with high search costs. The fourth category are the dynamic small microenterprises. These firms are generally isolated from international suppliers and buyers, and often domestic information networks. Fifth is the category of informal micro-survival enterprises, most of which have few prospects for growth into modern manufacturing in the long run. International evidence indicates that most of these enterprises die within a short life span; and most of those that survive over longer periods do not grow much. These firms should not be confused with more dynamic elements of private sector manufacturing.

The initial acquisition of technology for start-up of entrepreneur based firms, in categories two through four above in each of the countries, follows a similar pattern. Formal pre-investment feasibility studies are virtually non-existent amongst these firms: more than

[45] See the Ghana country case study in Chapter 7.

90 percent of the plants surveyed in the case studies in all the countries report undertaking no pre-investment feasibility studies. In some cases, entrepreneurs "followed their intuition" while in others they believed they knew the business well enough to be able to succeed without a formal evaluation of their investment, since the size of the initial operation was small and the implicit risk not too high. In other cases, where the investment entailed was large, either the market or inputs were secured. Among the few firms that did undertake feasibility studies, they were all large operations in categories one and two, they were manufacturing in relatively complex industries, such as metal working and food processing, and they undertook investment feasibility studies without outside assistance.

The case studies also show that entrepreneurs managed to develop their own purchasing strategies and skills at selecting and importing equipment. Local or foreign consultants and foreign partners assist in only about 5 to 10 percent of the cases. Differences in this pattern show up in MNCs and large firms with foreign equity investors. They often have choices made for them by their parent companies. Otherwise, entrepreneurs starting businesses generally have production experience in the industry; and hence have at least rudimentary knowledge of equipment and production processes necessary for efficient operation of the plant. In most cases, considering the relatively simple technologies needed to produce most of the labor-intensive products manufactured in these countries, previous production experience was enough to start up efficiently. In addition, foreign suppliers and their local distributors are another major source of technical information for potential investors. In Kenya, for example, a fourth of the case-study respondents, all local expatriates, undertook suppliers-arranged trips abroad to observe machinery before deciding on purchase. In Ghana, firms frequently hire foreign engineering firms for more complex processes, especially if purchasing new equipment. However, when purchasing used equipment, which is the overwhelming norm for start-up investment (Table 4.4), entrepreneurs search abroad themselves or rely on previous familiarity with the equipment. Table 4.4 also shows that new equipment is the usually the preferred choice for subsequent expansions to the firm. The reasons why firms, on average, start up with used equipment followed by new machinery for subsequent expansions appears to be a function of: (i) financial constraints and risk aversion at start-up; and (ii) cost of production and product quality considerations in subsequent additions to capacity. In all three countries, local markets for information-based services for entrepreneurs undertaking investment, in terms of local engineering firms and technical consultants, do not appear to be deep or well developed.

Table 4.4
Investments — Source and Vintage of Equipment Purchased

	Zimbabwe		Kenya		Ghana	
	Start-up	*Addition*	*Start-up*	*Addition*	*Start-up*	*Addition*
Source of Equipment						
Foreign	84	87	85	90	80	72
Local	16	13	15	10	20	28
State of Equipment						
Used	76	28	60	25	65	60
New	24	72	40	75	35	30

Source: RPED Survey Data, 1992-93.

Installation of equipment across the countries also follows a common pattern and is closely related to the source of equipment. For large firms (particularly in the case of new equipment), installation is most often done with assistance from foreign or local suppliers. Some training by suppliers in the use of newly-installed equipment is often included in the installation package for large firms; not surprisingly, larger firms undertaking more complex processes report a higher incidence of such training. Firms with foreign equity participation also rely on personnel from the foreign parent/partner. For smaller firms, equipment is usually less sophisticated and is generally installed by in-house personnel. Most of the firms, large and small, reported technical problems with equipment at start-up, ranging from breakdowns to failure to reach designed capacity. Other generic problems reported at start-up by many firms were problems achieving product and process specifications, and high proportions of rejects. These technical problems were solved for the most part within the firm through experimentation or via technical support from supplier and training of the personnel. On average, Zimbabwean firms exhibited the highest overall capability to debug these problems in-house, a legacy of the troubleshooting capability gained during the period of the UDI blockade. In Kenya, on the other hand. almost 42 percent of the firms in the case study needed outside help in commissioning the physical plant. Again, local engineering companies play an insignificant role in the installation or commissioning of new plants in both Kenya and Ghana.

At start-up, or in subsequent investments, adaptation of equipment to local conditions was made by only a few firms across the countries (see Table 4.5). Local capability to make such adaptations to foreign purchased equipment is not widely available. The larger firms, which have in-house engineering capability, are generally the only enterprises in a position to really make serious attempts at significant local adaptations. In each country, however, the case studies did find technicians in smaller firms tinkering with various kinds of simple equipment for local use. The stated reasons why firms made adaptations to new technologies varied across countries. One-third of the firms in Kenya and Zimbabwe stated that they made modifications to adapt to local material inputs, another one-third to reducing maintenance, and 15 percent made modifications to adjust to local energy sources. About 10 percent of the firms also stated that they had to make changes to newly purchased equipment to reduce the need for skilled operators because of their scarcity. In Ghana, adaptations were made mostly to reduce maintenance and use local materials. In Kenya and Zimbabwe, most of the technical adaptation of equipment which took place was done in-house (Table 4.6). Suppliers, particularly in Zimbabwe, also played a significant role, and to a lesser extent local or foreign personnel from the parent company gave some assistance. In Ghana, local technical assistance from a variety of sources was used by the firms that made technical modifications to equipment. These technical assistance sources ranged from other local firms and the technical colleges to, in one case, a foreign development agency. As might be expected, most of the technical adaptation in each country occurred in the metal working sector, where firms have in-house capability because of the nature of their work.

Table 4.5
Proportion of Firms Adapting Equipment Investment by Size
(Percent)

Firm Size (No. of Employees)	*Zimbabwe*	*Kenya*	*Ghana*
<10	9	14	8
10-49	4	12	7
50-99	17	16	10
100-249	22	19	5
250+	19		

Source: RPED Survey Data, 1992-93.

Table 4.6
Sources of Technical Adaptation — Percent of Firms Using each Source

Source	*Zimbabwe*	*Kenya*	*Ghana*
In-House	57	81	40
University or Technology Institute	0	0	0
Consulting Engineer	0	3	0
Equipment Supplier	33	6	15
Parent Company	5	0	0
Local Technical Assistance	5	10	45

Source: RPED Survey Data, 1992-93.

To sum up, the cross-country indicators on investment capabilities in Zimbabwe, Kenya and Ghana point up the fact that, in general, capabilities need improving in categories three and four of the enterprise ownership and size classification presented earlier. Multinational and local expatriate-run firms in each country generally have the necessary skills in-house or via the parent company to acquire technology and execute investment projects efficiently. A few indigenous large enterprises have sufficient capabilities to invest in complex industries. Most of the remainder, however, will need to upgrade their skills to move out of simple, labor-intensive activities. Zimbabwe, by all indicators, exhibits the highest level of national capability, followed by Kenya. More firms are investing and more firms have the capabilities to install and debug sophisticated equipment to make major equipment adaptations to improve their production efficiencies. Ghana, on average, appears to have fewer firms with the capability to make complex investments outside relatively simple technologies. Where Kenya and Zimbabwe exhibit shortcomings is in the uneven spread of their more advanced investment capabilities. Outside the white community in Zimbabwe and the Asian community in Kenya, black African entrepreneurs are less likely to possess the required investment capabilities to be able to enter.

Production Capabilities

Production capabilities of firms can be considered under two broad categories, namely, product capabilities and process capabilities. Product technological capabilities include improvements in product design or the introduction of new product designs. Process technological capabilities, on the other hand, refer to the comprehensive set of process related activities undertaken by firms subsequent to the installation and commission of the plant and equipment: for example, the design and layout of production, maintenance and repair of equipment to keep it running in an efficient manner, quality control mechanisms and industrial engineering.

Process Technological Capabilities

The technological needs of production processes vary from industry to industry. Furthermore, they are also dependent on the complexity of the production process which is often a function of the scale of manufacturing operations. This heterogeneity is evident in the firms in the four sectors of the three countries studied here. In broad terms, for the present set of manufacturing activities among these firms, garment manufacture has relatively the least demanding processes while certain forms of food processing and metal working the most demanding.

Ghanaian manufacturing firms in the sample are on the average smaller than those in the other two countries and display lower levels of process technological capabilities relative to firms in Kenya and Zimbabwe. This disparity holds even when only the larger firms are considered, as in the samples of the three country case studies. The relatively low process capabilities in Ghana are manifested in poor plant layout, badly maintained machinery and equipment, and limited ability of firms to do troubleshooting and repair in the event of malfunctioning of the equipment. As the case study on Ghana notes (Annex), process technological capabilities in Ghana are low not just in comparison to the other two Sub-Saharan countries considered here but in an international context also. For example, a comparison of large textiles and garments firms in the Ghanaian case study with similar firms in Sri Lanka shows that the former have almost half the percentage of total work force devoted to quality control procedures: 3.3 percent in Ghana compared to between 4.5 and 9.5 percent in Sri Lanka. Another telling example in this context is the case of a food-processing subsidiary of a leading MNC which has operations in practically all industrializing countries of the world. A worldwide comparison of productivity in 1992 by the head office of the MNC showed that the Ghanaian affiliate had the lowest productivity of all its operations worldwide. This provides an indication of how much further behind other local firms are likely to be, both in the food processing sector as well as the other sectors since the food sector in Ghana displays relatively higher process capabilities than the other three sectors.

In terms of troubleshooting, maintenance and repair of equipment, firms in Kenya and Zimbabwe show higher technological capabilities, at least relative to Ghana. The most common operational problem, reported by 54 percent of firms in the Kenyan case study and 76 percent of firms in Zimbabwe, was breakdown of equipment. This is not surprising given the age of machinery used by these manufacturing firms. Breakdown in the production process or process imbalances appeared to be another significant problem in the operations of firms in Kenya and Zimbabwe. In both countries, however, most large firms in the case-study samples seem well equipped for routine problem solving. Thus, almost 75 percent of the firms in the Kenyan case study reported having qualified personnel in-house to carry out repair and maintenance work. Of the 63 troubleshooting experiences reported by firms in Kenya, in almost two-thirds of the cases the problem was solved or in the process of being solved; in only four cases was no satisfactory solution attained. Furthermore, in more than 80 percent of the solved cases, the task was completed by in-house personnel. Simple tasks like oiling and replacement of belts and other similarly accessible parts could be carried out by one-third of the Kenyan sample while the remaining two-thirds of the firms were also able to carry out additional activities such as stripping most of the machines and replacing standard parts. At the same time, though, notwithstanding the presence of specialized personnel in the firms, only 13 of the 35 firms in the case study reported formal procedures for *preventive* maintenance, i.e., maintenance activities scheduled at fixed points in time even when the machines are running without experiencing breakdowns or need to replace parts.

In a similar vein, Zimbabwean firms have learned from necessity to be self-sufficient in order to maintain the physical plant. Given the relatively early vintage of machinery, breakdown of equipment in firms in the Zimbabwean case study was routine to the point that the main task of the plant manager was often to deal with breakdowns. However, almost none of the firms in this sample were found to be practicing preventive maintenance at the highest possible level. In terms of undertaking routine troubleshooting and repair, only three firms out of 41 were totally dependent on outside help (these were small plants in which the owner/manager did not have technical knowledge). At the other extreme, 6 firms had complete service in-house. Almost half the firms in the sample had the capacity not only to oil and replace accessible parts but also to strip most of the machinery, to replace standard parts or get spares made to order. For a majority of these firms, the most frequent maintenance task done outside the plant was rewiring of electric motors; in a few large plants, outside help was also obtained to insure that the annual overhauls of the main machines and equipment were done properly.

Firm specific efforts to control product quality and to improve plant productivity are additional good indicators of production capabilities in the process technology area. Beginning with quality control efforts, Table 4.7 shows the proportion of firms in Kenya and Zimbabwe involved in quality control across the production activities of the enterprise (data for Ghana on specific areas of quality control are unavailable). In all areas, Zimbabwean firms devote more effort to quality control than do Kenyan firms. Virtually all firms that were questioned in Zimbabwe had some kind of quality control system in place, especially in the area of final product inspection. But quality control also often extended to other activities, such as inspection of raw materials and components at time of purchase and at various stages of the production process. In Ghana, only 40 percent of the respondents claimed to have a formal (in the sense that specific employees are assigned to the task) quality control system in place. Most of these firms are in food processing, where virtually all firms do various kinds of testing to control the quality of the final product and to inspect material inputs. In the other sectors, only 25 percent of firms stated that they had any formal quality control system in place, although many firms stated they tried to make some sort of visual inspection in the final product stage, but often left final inspection up to the customer.

Table 4.7
Existence of Quality Control
(Proportion of Firms)

Existence of QC for:	*Kenya*	*Zimbabwe*
Final Product	77	98
Process	40	85
Purchases	57	83
Materials in Process	43	61

Source: RPED Case Study Data, 1993.

Table 4.8
Type of Quality Control Systems
(Proportion of Firms)

System	*Kenya*	*Zimbabwe*
No system	20	0
Visual, practical inspection	51	61
Lab tests, standards	29	39
Materials in Process	43	61

Source: RPED Case Study Data, 1993.

Comparatively, the observed levels of technical effort devoted to quality control in Ghana are quite low as against Kenya and Zimbabwe. But they seem even lower when they are pitted against the production processes of the average firm in other developing countries. As noted in the Ghana case study (see Chapter 7), the average garments firm in Ghana devotes only about one-third the manpower effort to quality control as does the average garments firm in Sri Lanka. Also, the nature of the quality control systems of firms in Zimbabwe and Kenya, even in the largest firms, do not appear very sophisticated on the whole (Table 4.8). Very few firms carry out control measurements or lab tests to comply with international norms or specifications. There is little statistical quality control. Today, however, this is beginning to change in Zimbabwe, where more sophisticated quality control procedures, like the Kawasaki Production System, are beginning to be incorporated into larger company production systems, particularly exporters. This type of activity, encompassing quality control with continuous improvement of plant productivity, may spill over to other firms as it comes into wider use. But right now, even larger firms, which have manual or computerized systems for inventory control and other activities, do not integrate these systems into production planning, nor do they generally have any systematic way to determine work standards other then the experience of the foreman or plant manager.

Finally, technical efforts to improve plant productivity are also a sound indicator of national production capability in process technologies. The RPED surveys show that very little organized activity to continually assess and improve productivity takes place in any of the countries (see Table 4.9). Even in Zimbabwe, only 21 percent of firms reported assigning personnel permanently to the task of plant productivity improvement. The case studies found most firms in all the countries organized their thinking around production or output targets, but they do not measure very precisely amounts of output obtained in relation to the quantities of inputs utilized. A number of firms professed to have a permanent interest in improving plant productivity, but their efforts were sporadic and no one was assigned responsibility for this function. In most cases, particularly for small and medium firms, but also for some larger enterprises, firms were also not aware of how their productivity stacked up against other firms in the same industry. Large, successful exporting firms were an exception.

Table 4.9
Firms with Personnel Permanently Assigned to Improve Productivity

Country	*Percentage of Firms*
Zimbabwe	21
Kenya	14
Ghana	10

Source: RPED Survey Data, 1992-93.

Product Technological Capabilities

Advanced product design skills are not in evidence among the firms in the three countries. Nor do any of the technical support institutions offer assistance in design. For the most part, firms copy existing local and foreign designs or follow customer-specified designs. Firms in all the countries do make modifications to copied designs to make use of local raw materials, to suit local tastes and to differentiate their products from those of rivals. In Zimbabwe, 80 percent of firms claimed to have made some modifications to the designs they had adopted; in Kenya, 50 percent of firms. In Ghana, there is some design modification activity, but efforts in this respect, on average, are much less sophisticated than those found in Kenya or Zimbabwe.

One of the expected outcomes of trade liberalization and the resultant foreign competition would be significant introduction of new products and product designs. In practice, however, little evidence to support this was found in any of the countries. Both in Zimbabwe and Kenya, about half the firms claimed they had introduced "new products" in the last few years. However, most of these, when investigated, were adaptations of products which exist elsewhere in the market. Very few firms in Ghana have even this level of product capability.

To put the design capabilities of these countries in perspective, studies of Korean manufacturers found that about 70 percent of the *small* enterprises surveyed had introduced a new product in the last three years, about half of which were significantly different from their existing designs (Kim and Nugent 1994). In Colombia, surveys also found that about two-thirds of small garment firms design everything they sell and an average of 85 percent of sales of machinery manufacturers are from own-designed products (Berry and Escandon 1994a).

Learning Mechanisms

The empirical findings on learning mechanisms in Ghana, Kenya and Zimbabwe reveal a similar pattern across the three countries, and in comparison to the rest of the world, as do the data on the previous two types of technological capabilities. Our discussion of these findings is organized around learning efforts that are internal to the firm as distinct from learning mechanisms external to the firm. Internal learning efforts consist of research and development, efforts at technical documentation and technical specialization within the firms, the use of expatriate and technical personnel, and on-the-job training of workers. Note though that training can occur both inside the firm as well as outside; it is therefore both an internal and external learning mechanism. Worker training is quantitatively the most important activity in all three countries and, consequently, occupies a central role in the discussion below. Finally, the discussion of learning mechanisms external to the firms differentiates between private learning mechanisms and collective learning mechanisms.

Internal Learning Efforts

Firms in Zimbabwe, Kenya and Ghana, to varying degrees, are engaged in on-the-job training of personnel, development of technical documentation, research and development activities and the hiring of specialized technical experts to build their technical capabilities. Where Zimbabwean, Kenyan and Ghanaian firms differ most is in the amount of effort committed to each of these sources of internal learning and the amount of complementary support these internal efforts get from external learning sources. We begin with a discussion of on-the-job and other firm-based training activities.

Enterprise Training

What does the pattern of training look like in low-income Africa? Do observed inter-firm and inter-sectoral variations in firm-based training found in Africa conform to the patterns found in industrial and semi-industrial countries? Before we answer these questions, let us briefly review what one expects to find based on the training literature in more industrialized countries. Studies in these countries cite several reasons why one might expect to observe considerable variation across firms and sectors in the amount and type of training provided. First, firms may be reluctant to invest in training if employee turnover is high. When employees leave the firm, the gains from training leak out and may even be enjoyed by rivals.

Second, training itself may contribute to employee turnover: if the skills imparted by training are valued by other firms, then the firm risks having employees "poached" by others. As a result, investments in non-portable, firm-specific training are more attractive to firms than investments in general training. Consequently, both employee turnover and the risk of poaching can lead to a failure of the market to provide optimal amounts of training, general training especially.

Third, firm size affects investments in training. Small firms often have higher training costs per employee than larger firms, because they can not spread the fixed costs of training over a large group of workers. The loss in production from having a worker in off-site training may also be higher for small enterprises than for large ones. Additionally, small firms, on average, exhibit higher employee turnover. For all these reasons, smaller firms generally train a smaller percentage of workers than do larger firms: for example, 26 percent of workers in large firms report receiving formal company training in the US, compared to 11 percent in small firms (Bowers and Swain 1992).

Fourth, employers are more likely to train workers who seem trainable. Evidence indicates that skilled workers, like technicians and managers, get more training than unskilled or manual workers (Lynch 1994). Consequently, the percentage of unskilled workers employed in firms will have an additional impact on the amount of training provided.

Fifth, enterprise training will also be influenced by the amount and quality of education workers receive before entering the work force, and by the training available to workers in the early years of their employment. That is, what happens in schools influences how much training employers must do and how much it will cost to achieve the skill quality of employee they require (Lynch 1994).

Lastly, as we noted earlier, the amount firms invest in new technologies is closely linked to the amounts they invest in training (Aw and Tan 1994). This suggest that inter-firm and inter-industry variations in training are driven partly by the skill requirements of adopting and implementing technical change.

It is well known that investments in training and human capital can be less than socially optimal due to market failures. The extent of market failure in the provision of training would be abated if capital markets were more perfect and workers could borrow to finance more training, if the state subsidized training, or if employers could pay workers lower wages during training periods. To some degree, in all countries, capital markets, governments and employee compensation schemes do play an important role in reducing market failures in enterprise training. But, in Africa, capital markets suffer from greater imperfections, the state has not done a good job in providing effective vocational training or training incentives to firms, and government regulations and unions have constrained employer wage flexibility. As a result, the failure of markets to provide optimal amounts of training goes largely unabated.

In addition, Africa's manufacturing sectors are populated by relatively large groups of small enterprises and by unskilled workers, reducing overall incentives for firm-based training. Small-scale enterprises also commonly suffer greater financing difficulties which may lead to under-investment even in specific training by such firms. Furthermore, the number of students enrolled in schools of all kinds in Africa is relatively low and the quality of education in these schools is comparatively lower. Consequently, the levels of training needed to develop internationally competitive skill proficiencies is higher than in other regions of the world. Hence, while equal investments in training would have a "bigger bang for the buck" in Africa, the size of investments needed to reach comparable levels of competitiveness may be too large for African firms to undertake. As a result of these factors, one might expect that market failures in the provision of firm-based training in Africa are greater than in other parts of the world, and therefore one would expect to observe lower levels of training and perhaps higher inter-firm and inter-sectoral variance in training.

We now turn to the survey data on training in Ghana, Kenya and Zimbabwe.[46] For new entrants to the work force, virtually all firms in the sample put shop-floor employees through some kind of training. The duration, rigorousness and formality of the training depend to a large extent on the nature of the tasks to be learned and the size of the firm doing the training. Multinationals and larger domestic firms are the only enterprises that conduct

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[46] Data was collected regarding formal and informal training in firms in all three countries. In the end, formal, in-house training was observed in only a few large enterprises. As a consequence, the training variable used here includes both formal and informal types of training, but distinguishes between training conducted inside the firm and training conducted externally.

any formal training. Entry-level, in-house training in many of these enterprises tends to include a combination of some formal training (usually very little) and some informal, on-the-job training. Smaller enterprises engage in less structured, on-the-job training.

Most new shop-floor workers in medium and large firms are designated "trainees" and receive a training wage, which is lower than the wage for a more experienced employee. In small enterprises, particularly in West Africa, apprenticeship is also quite important. Apprenticeships are most prevalent in informal, small firms, which seem to operate as both training and manufacturing businesses in many cases. In Ghana, apprenticeship has become a kind of semi-formalized, informal training system, whereby young, primary or middle school leavers pay firms to learn from master craftspersons or technicians. Apprentice training is largely training-by-working, working alongside an experienced person. Unlike its European counterpart in, say, Germany, the apprenticeship generally involves little or no further formal education (although some apprentices do take courses on their own at Polytechnics on a part-time basis) and is geared towards transferring relatively simple manufacturing skills, which do not change much over time.

Apprenticeships vary in duration by sector — 6 months to 2 years or so for furniture, 2 to 5 years for metal working. As the apprentice progresses into more advanced stages of the program, he or she is often given a small allowance by the firm, if and when business is good, but this allowance is generally much less than the going wage. Apprentices are found most often in small garments, furniture and metal working firms. The structure of the apprenticeship system, as constituted in West Africa, is not well-suited to training more educated workers for skills needed for modern manufacturing, and thus is not generally used by larger enterprises. It should be noted, however, that apprenticeship is also known in Zimbabwe, where government parastatals have traditionally had limited, entry-level apprentice programs. This form of apprenticeship is somewhat different than its West African counterpart, in that apprentices do not pay the employer to enter the program. In fact, the apprentice is paid the entry-level wage. The Government of Zimbabwe has largely discontinued this program in recent years.

Another form of firm-based training conducted by manufacturing enterprises in Ghana, Kenya and Zimbabwe is of a more continuous nature. Firms invest in continuous training of existing, experienced workers to maintain and upgrade skills and/or to impart new skills. Tables 4.10 and 4.11 present data on the proportion of firms engaged in this type of training and the proportion of employees involved in training at the time of the interviews.

As Table 4.10 indicates, there is a great deal of variation across firms in the incidence of continuous training. In all three countries, it is the larger enterprises, as expected, which invest in training experienced workers. The training can be both formal and informal (depending on the firm size), of widely varying duration and is geared largely to the specific production requirements of the firm, rather than aimed at any general upgrading of personnel. In many large firms, in-house training is often conducted using experienced expatriate personnel who are brought into the firm to be production managers as well as trainers. In the case of multinationals, the pattern most often followed is that parent company personnel are sent to Africa periodically to run training courses for local staff in areas like quality control and other production-related topics. If small enterprises do any in-house continuous training, it is generally training-by-watching on the job.

Table 4.10
Proportion of Firms Currently Engaged in Continuous Training for Shop-floor Workers
(By Firm Size and Sector — Percent)

	Zimbabwe		*Kenya*		*Ghana*	
	In-House	*External*	*In-House*	*External*	*In-House*	*External*
Firm Size						
<10	4.4	11.1	8.2	2.7	4.9	1.6
10-49	20.6	26.5	12.2	16.3	21.9	6.2
50-99	29.0	41.9	16.2	32.4	31.2	31.2
100-249	46.7	62.2	34.1	41.5	50.0	31.8
250+	58.1	74.4				
Sector						
Food Processing	28.6	49.0	14.6	18.8	15.8	7.9
Textile and Garments	31.8	44.7	10.2	14.3	8.8	2.9
Wood working	23.1	34.6	18.0	28.0	23.9	15.2
Metal working	43.2	40.5	20.8	17.0	28.9	13.3

Source: RPED Survey Data, 1992-93.

Table 4.11
Proportion of Shop-floor Employees Currently Engaged in Continuous Training
(By Firm Size and Sector — Percent)

	Zimbabwe		*Kenya*		*Ghana*	
	In-House	*External*	*In-House*	*External*	*In-House*	*External*
Firm Size						
<10	1.4	2.4	3.3	0.9	3.1	4.0
10-49	6.6	4.6	2.3	2.8	3.3	3.1
50-99	4.9	5.9	2.1	6.1	5.9	3.0
100-249	10.7	12.5	6.0	6.8	8.5	5.1
250+	14.2	22.9				
Sector						
Food Processing	9.2	14.7	3.7	4.0	4.4	3.1
Textile and Garments	6.8	10.2	2.2	3.7	2.6	.9
Wood working	5.7	7.7	3.8	6.1	8.9	4.1
Metal working	13.5	10.9	4.1	4.1	9.6	4.4

Source: RPED Survey Data, 1992-93.

In terms of the number of shop-floor workers engaged in training at any point in time, firm size appears to be the most important determinant. Larger firms in each country have the highest proportion of workers in training (see Table 4.11). And, on average, with the exception of Ghana, there are more employees engaged in external training than in-house training. Again, Zimbabwe's firms appear to have the largest number of employees involved in training at any time.

Sectorally, the picture is somewhat mixed, but firms in metalworking have slightly more firms and employees engaged in training than other sectors, followed by food processing and wood working. This outcome is not surprising considering the relative ranking of the technological complexity of these industries.

African firms also send workers for external training. External training, as these data indicate, is more prevalent in Zimbabwe and Kenya than in-house training. Further, while both large and small firms engage in more external training, a higher proportion of larger enterprises send employees for external courses than do small enterprises. The courses attended range from one-day training exercises to longer-term programs at local technical schools. External training is carried out domestically and sometimes abroad. For example, multinationals often send employees for foreign training to the parent company headquarters. By country, the extent of external training depends importantly on the availability of local institutions providing industry-specific courses. In this respect, Zimbabwe's more extensive array of technical schools and privately-provided training courses provide more training alternatives than do institutions in Kenya and Ghana. Similarly, the relatively low numbers for external training in Ghana appear to reflect the lack of external, industry-specific training courses available to Ghanaian firms.

Interestingly, entrepreneurs, too, attend external training courses (Table 4.12). Almost half of the entrepreneurs in Zimbabwe attended external training courses in 1992. Most of these courses were in the field of general management (42 percent) rather than of a technical nature (only 18 percent). Fewer entrepreneurs went outside the firm for training in Kenya and Ghana, but, when they did, it was generally to attend management rather than technical courses. On average, across all the countries, entrepreneurs from smaller firms went to external training more than entrepreneurs from larger firms. Given that most of these small enterprises are run by African entrepreneurs, it is not surprising to find that Africans make up a large proportion of the entrepreneurs attending external courses in Zimbabwe and Kenya.

Table 4.12
Zimbabwe, Kenya and Ghana — Entrepreneurs Attending External Training Courses in 1992
(Percent)

	Proportion of all Entrepreneurs	*Type*			*Firm Size*				*Ethnicity*			
		Management	*Technical*	*Other*[a]	*1*	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Zimbabwe	43	42	18	40	31	22	18	29	16	40	40	4
Kenya	25	58	24	18	38	31	20	11	40	0	60	0
Ghana	19	43	33	24	24	43	14	19	n/a	n/a	n/a	n/a

[a]Accounting and courses on marketing, etc.

Firm Size: 1 = <10 employees; 2 = 11-49 employees; 3 = 50-99 employees; 4 = 100-249 employees in Zimbabwe and Kenya; for Ghana, 4 = 100 employees or greater (No owner-entrepreneurs were found in the >250 employee size category)

Ethnicity: 1 = Asian; 2 = European; 3 = African; 4 = Other

Source: RPED Survey Data, 1992-93.

What seems important from the training data we have been able to gather in Africa is that firms appear willing to expend resources on training their workers. While it is difficult to measure the quality of in-house and external training programs undertaken, evidence shows that firms are trying to raise worker capability. To give some perspective to the African training data, we can compare them with some figures available for advanced and semi-industrial countries.

Comparisons can be made with rough measures of formal enterprise training in advanced countries (Table 4.13). Considering that our data for Africa include informal training, strict comparisons are not possible. However, there is an indication in these figures that the incidence of enterprise training in Africa, as might be expected, is generally much lower than in advanced countries, particularly formal training. For example, taking the training data for Japan, which is approximately comparable with our survey data in that it examines the proportion of workers receiving training within the recent past, the average for Zimbabwe for total training (in-house and external), including formal and informal, is only about one-fifth the number of workers trained, and in Kenya it is much less.

While the incidence of training appears lower in Africa, the inter-firm and inter-sectoral patterns appear similar. Enterprise size is an evident determinant of firm-based training in Africa and this squares with what is found in the rest of the world. Tan and Batra (1995), for example, find that in semi-industrialized countries, like Taiwan, 38 percent of large firms formally train workers in-house, while the corresponding figure for small firms is only 4 percent. In Zimbabwe, the comparable figures (which include formal and informal training) are 52 percent for large firms and 17 percent for small; in Kenya, 34 percent for large and 12 percent for small; in Ghana, 50 percent for large and 18 percent for small. Looking at this issue in terms of the number of workers trained, comparisons can be made again with Japan. At any point in time, large firms in Japan (1,000 or more employees) have about 18 percent of their employees engaged in in-house, on-the-job training programs and 30 percent engaged in in-house, off-the-job training, for a total of 48 percent. The comparable figures for small firms (30-99 employees) are 8 percent involved in in-house, on-the-job training and 24 percent in in-house, off-the-job training (Dore and Sako 1992). Thus, large firms in Zimbabwe or Kenya train only a fraction of the workers in-house that Japanese small firms train, but a similar differential is evident between in-house training in large and small firms, although the differential in the proportion of workers trained is much larger in Africa.

Table 4.13
Enterprise Training in Advanced Industrial Countries

Country	*Individuals Receiving Formal Training (Percent)*
United States: 1983	11.8[a]
1991	16.8[b]
Canada: 1985	6.7[b]
West Germany: 1989	12.7[b]
Great Britain: 1989	14.4[b]
France: 1990	32[c]
Netherlands: 1986	25.0[b]
Sweden: 1987	25.4[b]
Japan: 1989	36.7[d]
Australia: 1989	34.9[e]
Norway: 1989	33.1[b]

[a]Received training at any time in current job.
[b]Of all employed workers.
[c]Of all workers in firms employing 10 or more employees.
[d]Received training within the past two years.
[e]Received in-house training.
Source: Lynch, Lisa (ed), 1994. *Training and the Private Sector.* National Bureau of Economic Research Comparative Labor Market Series. University of Chicago Press.

Tables 4.14-4.16 set out comparable enterprise training figures for several low income and semi-industrial countries in Asia and Latin America. In terms of in-house formal training, African firms continue to appear low, although we do not have precise figures for Africa. However, Colombia, Indonesia and Mexico do not seem to be much farther advanced in formal training. Under the extreme assumption that all external training in Africa is formal training (probably not a bad assumption, considering workers are usually attending courses at formal training institutions), then Africa compares favorably with these other countries. Zimbabwe even outperforms some of its Asian and Latin American rivals. On the other hand, if some proportion of the external training of workers is not formal, then the figures for African firms would appear relatively lower than the other countries, although still broadly comparable.

Looking at the more comparable informal training figures, Africa seems to compare very closely with Indonesia and Mexico, while more industrialized countries, like Malaysia and Colombia, have higher overall incidence. Again, the pattern of training across firm size classes appears very similar across all the countries.

Table 4.14
Incidence of Training by Type and Source
(Percent of Firms Training)

	Colombia (1992)	*Indonesia (1992)*	*Malaysia (1994)*	*Mexico (1992)*	*Taiwan (1986)*	*Zimbabwe (1993)*[a]	*Kenya (1993)*[a]	*Ghana (1994)*[a]
Sample Size	500	300	2,200	5,072	56,047	200	223	179
% Informal Training	75.9	18.5	83.1	11.3	n/a	32.3	16.0	23.7
% Formal Training from any Source	49.6	18.9	34.7	10.8	9.29	n/a	n/a	n/a
% Internal Formal Training	3.7	9.7	25.2	5.8	n/a	n/a	n/a	n/a
% External Formal Training	48.7	14.2	20.4	7.9	n/a	43.9	19.5	12.7

[a]For Africa, we assume that all internal training is informal and all external training is formal. However, some (very few) large multinational firms have internal formal training courses.

Source: For Colombia, Indonesia, Malaysia and Mexico: Tan, H. and G. Batra (1995). "Enterprise Training in Five Developing Countries: Overview of Incidence, Determinants and Productivity Outcomes." Paper presented at the Conference on Enterprise Training Strategies and Productivity, Private Sector Development Department . World Bank, Washington, DC.

For Zimbabwe, Kenya and Ghana: RPED Survey 1992-93.

Table 4.15
Incidence of Informal Training by Firm Size
(Percent of Firms Training)

Firm Size	*Colombia (1992)*	*Indonesia (1992)*	*Malaysia (1994)*	*Mexico (1992)*	*Firm Size (Africa)*	*Zimbabwe (1993)*[a]	*Kenya (1993)*[a]	*Ghana (1994)*[a]
<15	67.6	n/a	56.5	7.4	<10	4.4	8.2	4.9
21-100	77.8	15.7	80.5	36.1	10-49	20.6	12.2	21.9
101-250	88.6	32.6	88.8	44.7	50-99	29.0	16.2	31.2
>250	87.2	16.1	92.4	30.4	100-249	46.7	34.1	50.0
					>250	58.1		

[a]For Africa, we assume that all internal training is informal and all external training is formal. However, some (very few) large multinational firms have internal formal training courses.

Source: *For Colombia, Indonesia, Malaysia and Mexico:* Tan, H. and G. Batra (1995). "Enterprise Training in Five Developing Countries: Overview of Incidence, Determinants and Productivity Outcomes." Paper presented at the Conference on Enterprise Training Strategies and Productivity, Private Sector Development Department , World Bank, Washington, DC.

For Zimbabwe, Kenya and Ghana: RPED Survey 1992-93.

Table 4.16
Incidence of External Training by Firm Size
(Percent of Firms Training)

Firm Size	*Colombia (1992)*	*Indonesia (1992)*	*Malaysia (1994)*	*Mexico (1992)*	*Firm Size (Africa)*	*Zimbabwe (1993)*[a]	*Kenya (1993)*[a]	*Ghana (1994)*[a]
<15	32.8	n/a	5.1	3.9	<10	11.1	2.7	1.6
21-100	50.9	10.9	8.1	30.1	10-49	26.5	16.3	6.2
101-250	76.8	17.7	25.6	45.7	50-99	41.9	32.4	31.2
>250	81.3	28.8	50.8	40.2	100-249	62.2	41.5	31.8
					>250	74.4		

[a]For Africa, we assume that all internal training is informal and all external training is formal. However, some (very few) large multinational firms have internal formal training courses.

Source: *For Colombia, Indonesia, Malaysia and Mexico:* Tan, H. and G. Batra (1995). "Enterprise Training in Five Developing Countries: Overview of Incidence, Determinants and Productivity Outcomes." Paper presented at the Conference on Enterprise Training Strategies and Productivity, Private Sector Development Department . World Bank, Washington, DC.

For Zimbabwe, Kenya and Ghana: RPED Survey 1992-93.

All in all, although levels of training are relatively lower, Africa does not come out as badly as one might expect in this comparison of training incidence. One notable fact is the similarity between Indonesia and Africa. In almost all categories, Indonesian firms appear similar to African firms. In the most comparable category of informal training, Zimbabwean firms even outperform Indonesian firms on average. It would appear, therefore, that countries with similar per capita incomes and firm size distributions have similar levels of training incidence.

Who actually receives training is another important issue. In the US, the workers who receive enterprise training are primarily technical and managerial employees with university degrees (Bartel 1991). Non-managerial and non-technical workers receive more training in Europe and Japan than in the US, but still much less than managerial and technical employees. In Africa, the same holds true. Tables 4.17, 4.18 and 4.19 present data on in-house and external training by type of worker. In each of the countries, training is lavished mostly on skilled personnel. Administrative and clerical staff, skilled production workers and machinery operators, and technicians, like electricians and plumbers, received about 65 percent of the training provided in each country.

Table 4.17
Workers Currently Receiving Training in Zimbabwe by Job Category
(Percent)

Worker Category	*In-house*	*External*
Management	8	12
Administrative/Clerical	16	27
Supervisory/Foremen	13	7
Skilled Production Workers	17	11
Other Production Workers	10	8
Support Staff	0	6

Source: RPED Survey Data, 1993.

Table 4.18
Workers Currently Receiving Training in Kenya by Job Category
(Percent)

Worker Category	*In-house*	*External*
Management	11	16
Skilled Administrative/Clerical	18	28
Supervisory/Foremen	7	7
Skilled Production Workers	7	4
Other Production Workers	6	7
Support Staff	0	6

Source: RPED Survey Data, 1993.

Table 4.19
Workers Currently Receiving Training in Ghana by Job Category
(Percent)

Worker Category	*In-house*	*External*
Employed Management	3	5
Technician	1	
Skilled Office and Accounting	15	24
Assistant and Specialized Sales	6	5
Foremen and Supervisors	6	5
Electricians and Plumbers	12	3
Machine Operators	12	13
Laborers and Helpers	4	3
Ind. Specially Skilled	22	22

Source: RPED Survey Data, 1992.

In sum, an examination of enterprise training in Africa indicates a number of similarities with the rest of the world, but also a number of important differences. To begin, patterns in the incidence of training across firms are similar: small firms train much less than large firms; foreign-owned firms train more than local firms; and exporters are more likely to train than domestic producers (See Table 4.20). Training methods are also similar in that African firms also use in-house and external sources to train workers and rely heavily on on-the-job training. African firms, like firms the world over, also train managers and skilled workers more than their non-managerial, non-technical compatriots. Where African firms appear to differ most from those in other regions is in the overall incidence of training, both formal and informal. Enterprise training appears much lower in Africa, formal training in particular. This deficit in training is even greater when one considers the need for training to reach internationally competitive skill proficiencies, given the lack of experience in manufacturing and the quality of vocational and general education available. This is a subject to which we now turn.

Table 4.20
Training by Foreign-owned Firms and Exporters in Zimbabwe, Kenya and Ghana
(Full Sample — Percent)

Firms	*In-house*	*External*
Foreign-owned	47	9
Domestic	17	27
Exporters	38	31
Non-exporters	18	8

Source: RPED Survey Data, 1992-93.

Scarcity Factors in the Pool of Work Force Talent and the Need for Training. The effectiveness of training in a firm and its impact on learning will depend on the firm-specific assets it can employ in the learning process and on the external learning sources it can draw upon. The firm's assets include the quality of the workers it is able to recruit, the quality of the training staff it can deploy to train workers and the training methods they can effectively utilize, as well as the commitment of management to developing a "learning organization," including the incentives it can provide workers to learn — for example, paying for off-the-job learning time and linking newly gained qualifications with marginal pay boosts. In most cases, these internal resources will not be sufficient to meet the firm's needs and must be supplemented and reinforced by external resources.[47]

Scarcity factors in the pool of shop floor talent are a big problem in Africa. In terms of all the basic indicators, such as the adult illiteracy rate, educational attainment of target populations, pupils enrolled in vocational education and the stocks of technical and scientific personnel, Sub-Saharan Africa lags the rest of the world (Tables A1, A2, A3 and A8 in Appendix A). Zimbabwe, Kenya and Ghana all do much better than the average for the region in these areas, but they fall far short of the rest of the world. Only Zimbabwe has been able to reach Latin American averages for primary and secondary educational attainment. In vocational training, and general science and engineering, the comparative statistics reveal an even larger gap. What these numbers imply is an extremely ill-educated industrial labor force. This, and the fact that accumulated industrial experience is also low, have important implications for enterprise training needs and for the cost and effectiveness of training methods.[48]

Training methods and costs are affected by the pool of shop-floor talent. Using Japan again to make a comparison, the formal education system in Japan produces a very high level of general literacy in the work force. Workers are capable of following very detailed and complex written instructions. This means that a lot of learning is based on informal production of job specifications and procedures manuals meticulously written out by supervisors and used as teaching material for self-teaching by newcomers to a job. A junior employee does not just stand by the supervisor; he or she reads what the supervisor has thoughtfully and meticulously written about what he or she knows (Dore and Sako 1989, p. 16). In Africa, very little of this type of learning takes place because the level of general literacy is so low. In both Zimbabwe and Kenya, 50 percent of the firms surveyed used no

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[47] Industry-specific technical courses, linkages with other firms in the business, interaction with buyers and suppliers and direct support services from government and business associations are all potential external resources firms can draw on. These external learning mechanisms are discussed later in the chapter.

[48] The critical need for training is evidenced by the fact that in all three countries, employee training is invariably at the top of the list of managers' most desired support services (see Tables 4.30 and 4.31). Moreover, respondents also stressed that low levels of education and accumulated production experience of shop floor workers increased substantially the requirement for supervision in their factories. Plants in Africa, we were told by expatriate managers, require more supervisors, foremen and managers per shop floor worker than plants in other parts of the developing world and this has detrimental effects on production costs.

technical documentation or procedures manuals and another 30 percent used very little documentation. In Ghana, the use of documentation and procedures manuals is even lower (see Chapter 7). Thus a focus on high literacy and numeracy in the school system can lower the cost of a firm's investments in training and productivity improvement. Because of the high level of basic knowledge the work force shares in Japan, firms can rely more on informal learning and on individual study for technical training.

Hence, underinvestment in training in Africa can take two forms. First, African firms are generally spending less and providing workers with lower quality training than competitors in other developing countries. Second, the level of spending or training quality might be the same but, because of lower human capital at entry, training is still not sufficient to achieve the skill proficiencies found in competitor countries.

Scarcity factors in technical personnel are also constraining in Africa. Without adequate supplies of such key personnel, the effectiveness of enterprise training and supervision is reduced and is often more costly because it has to be outside the firm. Table 4.21 shows the proportion of technical personnel found in the case studies in all three countries. The totals are exceptionally low, even compared to other developing regions. Zimbabwe, again, for each industrial category, has a higher level of human resources available. The proportion of technical personnel employed in all sectors averages about twice that of Ghana. This gives Zimbabwe an important manpower advantage.

Table 4.21
Technical Personnel as a Percentage of Total Personnel in Zimbabwe, Kenya and Ghana

Sector	*Ghana*	*Kenya*	*Zimbabwe*
Food Processing	2.9	5.3	7.2
Textile and Garments	2.1	3.1	4.3
Wood working	2.0	1.2	12.4
Metal working	5.4	6.8	7.6
Total	3.1	4.1	7.9

Source: RPED Case Studies, 1992-93.

Another important element of firm-specific human capital where scarcity factors can be observed in Africa is management. The RPED surveys gathered information on the educational attainment of owner-entrepreneurs across the countries. These data are shown in Tables 4.22-4.24. The surveys assessed the general level of education, as well as the proportion of entrepreneurs attending technical schools. Firm size and ethnic backgrounds of entrepreneurs were also taken into consideration.

Looking first at the proportion of entrepreneurs with higher levels of education in each country, it is clear that Zimbabwe's entrepreneurs, on average, embody superior accumulations of human capital. More than 80 percent have secondary or university degrees, as against 70 percent and 40 percent in Kenya and Ghana, respectively. It is interesting to note, however, that African entrepreneurs in Zimbabwe have slightly lower general educational attainments than African entrepreneurs in Kenya (unfortunately, we have no comparable data for Ghana). As one might expect, the tables also indicate that entrepreneurs running large firms are more likely to have higher education than entrepreneurs running small firms in all countries. Additionally, Asian and European managers in these countries have higher average educational attainments than African managers.

Table 4.22
Zimbabwe — Education of Entrepreneurs
(Percent)

	Proportion of all Entrepreneurs	*Firm Size*				*Ethnicity*			
		1	*2*	*3*	*4*	*1*	*2*	*3*	*4*
No Education	2	3	5	0	0	0	0	5	0
Primary	21	43	14	13	6	10	6	40	33
Secondary	53	40	52	65	45	32	58	49	33
University	31	13	29	22	48	58	35	5	33

Firm Size: 1 = <10 employees; 2 = 11-49 employees; 3 = 50-99 employees; 4 = 100-249 employees. (No owner-entrepreneurs were found for enterprises with 250 or more employees.)
Ethnicity: 1 = Asian; 2 = European; 3 = African; 4 = Other.
Source: RPED Survey Data, 1993.

Table 4.23
Kenya — Education of Entrepreneurs
(Percent)

	Proportion of all Entrepreneurs	*Firm Size*				*Ethnicity*			
		1	*2*	*3*	*4*	*1*	*2*	*3*	*4*
No Education	2	3	4	0	0	2	0	3	0
Primary	27	49	13	14	7	13	0	47	100
Secondary	45	40	49	54	45	52	90	38	0
University	25	8	34	32	48	33	10	13	0

Firm Size: 1 = <10 employees; 2 = 11-49 employees; 3 = 50-99 employees; 4 = 100-249 employees. (No owner-entrepreneurs were found for enterprises with 250 or more employees.)
Ethnicity: 1 = Asian; 2 = European; 3 = African; 4 = Other.
Source: RPED Survey Data, 1993.

Table 4.24
Ghana — Education of Entrepreneurs
(Percent)

	Proportion of all Entrepreneurs	*Firm Size*			
		1	*2*	*3*	*4*
No Education	7	10	7	0	0
Primary	54	65	57	22	22
Secondary	25	21	30	56	0
University	13	4	7	22	78

Note: Data on Ethnicity was not collected in Ghana.
Firm Size: 1 = <10 employees; 2 = 11-49 employees; 3 = 50-99 employees; 4 = 100-249 employees. (No owner-entrepreneurs were found for enterprises with 250 or more employees.)
Ethnicity: 1 = Asian; 2 = European; 3 = African; 4 = Other.
Source: RPED Survey Data, 1992.

Lastly, about one-quarter to one-third of the entrepreneurs surveyed attended technical school, depending on the country of origin (Table 4.25). Zimbabwe had a slightly higher number of technical school graduates. Of the 33 percent of entrepreneurs attending technical school in Zimbabwe, 43 percent were Europeans and 40 percent were African. In Kenya, it was 53 percent Asians and 44 percent Africans. These figures, however, do not tell the whole story of the importance of vocational school for African entrepreneurs. Given that African entrepreneurs make up a smaller proportion of the manufacturing firm population in each country, one must ask the question: What is the likelihood that any African entrepreneur would have a technical school education? The answer in Zimbabwe is that about 40 percent of all African entrepreneurs in the sample have a technical school education (30 percent for European entrepreneurs), while in Kenya it is 26 percent (20 percent for Asians). Also, Table 4.25 indicates that small firm entrepreneurs are more likely to have technical school educations than large firm entrepreneurs.

Table 4.25
Zimbabwe, Kenya and Ghana — Entrepreneurs with Technical School Education
(Percent)

	Proportion of all Entrepreneurs	*Firm Size*				*Ethnicity*			
		1	*2*	*3*	*4*	*1*	*2*	*3*	*4*
Zimbabwe	33	31	26	17	26	17	41	40	0
Kenya	25	42	24	18	16	53	2	44	0
Ghana	25	36	36	18	11	n/a	n/a	n/a	n/a

Firm Size: 1 = <10 employees; 2 = 11-49 employees; 3 = 50-99 employees; 4 = 100-249 employees. (No owner-entrepreneurs were found for firms with 250 or more employees.)
Ethnicity: 1 = Asian; 2 = European; 3 = African; 4 = Other.
Source: RPED Survey Data, 1992-93.

Research and Development

Another important internal learning mechanism is R&D. Since most technology in Africa is imported from more industrialized countries, one would not expect to find much innovation-oriented R&D going on in Zimbabwe, Kenya or Ghana. One does expect, however, to observe technical efforts going on to modify imported equipment, to differentiate local product designs, to re-engineer or copy foreign machinery and goods, and so on. Indeed the RPED surveys and case studies did pick up such activities. A good deal of what might be called informal tinkering, imitating, adapting and experimentation is evident in African firms of all sizes. Only a few large firms, however, conduct any formalized R&D in the sense that personnel are more or less assigned, on a continuing basis, to such tasks and there is a fixed budget applied to the activity.

In the RPED survey, firms were asked whether they had undertaken any systematic activity in the preceding year (1992) to increase the stock of knowledge in the enterprise, including fundamental research, applied research and experimental development leading to new machinery or other devices, products or processes.[49] They were also asked how many employees spent time in these activities and what were their educational backgrounds, as well as how much was spent on these activities? The results are reported in Tables 4.26 and 4.27.

[49] Respondents were prompted not to consider as R&D any routine maintenance or quality control activities, even if scientists or engineers were employed in carrying it out.

Table 4.26
Proportion of Firms Involved in R&D Activity, 1992

Country	*Percentage*
Zimbabwe	26
Kenya	15
Ghana	10

Source: RPED Survey Data, 1992-93.

Table 4.27
Average Expenditure on R&D by Sector, 1992
(Current US$ per Worker)

Sector	*Zimbabwe*	*Kenya*	*Ghana*
Food	37.8	10.8	0
Textile and Garments	18.6	4.8	0
Wood	41.6	2.2	2.7
Metal	31.6[a]	6.0	0.9

[a]One very large firm spent more than US$2 million in 1992 on R&D. This outlier was removed.
Source: RPED Case Study Data , 1992-93.

As Table 4.26 indicates, a very small proportion of firms engage in formal R&D. Zimbabwe has the highest proportion of firms involved in formal R&D and these firms, on average, spend more on these activities than firms in Kenya and Ghana. This holds across each of the sectors. Food processing, wood working and metal working are the industries where most of Zimbabwe's R&D activity takes place, as might be expected by the concentration of the country's scientists and engineers in these sectors (see Table 4.28). Similar patterns of activity hold for Kenya and Ghana. Ghana's lack of organized R&D activity and Zimbabwe's higher levels of R&D are not surprising. Zimbabwe is better off than Ghana in terms of the human capital in industrial enterprises and, as noted earlier, produces a more complex and diverse set of products. But Zimbabwe's relative advantages in Sub-Saharan Africa do not translate into advantages in the rest of the world. By international standards, Zimbabwe's R&D efforts appear relatively small, even for developing countries (Tables A5 and A7 in Appendix A). Many of its firms do not have the capability to carry out sophisticated R&D activities. Zimbabwean firms, with the exception of a few large multinational corporations and business groups, have very few personnel with the experience and qualifications to undertake R&D activities. While Zimbabwe is better off than Kenya and Ghana, Table 4.26 also indicates that Zimbabwe's current stock of scientists, engineers and technicians is exceedingly low as a percentage of total employment. Moreover, most of these scarce key personnel are concentrated in a few big firms (see Table 4.30) and in a few sectors, like food processing, where scientists spend most of their time doing quality control lab tests and not R&D.[50]

Table 4.28
Zimbabwe — Employment of Scientists, Engineers and Technicians by Sector

Sector	*Total Employment*	*Scientists* *No.*	*%*	*Engineers* *No.*	*%*	*Technicians* *No.*	*%*
Food	15,983	103	0.64	22	0.14	280	1.75
Textiles	2,496	1	0.00	38	0.12	58	2.32
Wood	32.411	0	0.00	3	0.12	353	1.09
Metal	5,479	1	0.02	31	0.57	115	2.10
Total	56,369	105	0.19	94	0.17	806	1.43

Source: RPED Survey Data, 1993.

Table 4.29
Technical Personnel as a Percentage of Total Personnel in Zimbabwe, Kenya and Ghana

Sector	*Ghana*	*Kenya*	*Zimbabwe*
Food Processing	2.9	5.3	7.2
Textile and Garments	2.1	3.1	4.3
Wood working	2.0	1.2	12.4
Metal working	5.4	6.8	7.6
Total	3.1	4.1	7.9

Note: Technical personnel include scientists, engineers and highly-educated technicians.
Source: RPED Survey Data, 1992-93.

Table 4.30
Zimbabwe — Concentration in Employment of Scientists, Engineers and Technicians

Personnel	*Total No.*	*No. of Employing Firms*	*No. Employed by Three Largest Employers*	*% of Total Number*
Scientists	105	8	91	86.67
Engineers	94	21	50	48.08
Technicians	806	52	373	46.28

Source: RPED Survey Data, 1993.

[50] The same is true of technical personnel in Kenya and Ghana, as is indicated by Tables 6.17 and 6.18, and Tables 7.12 in each country study, respectively.

Technical Documentation and Technical Offices

Technical documentation helps employees learn about sophisticated domestic or foreign products and presentation technologies, for example, by facilitating re-engineering, and assists in on-the-job training and diffusion of knowledge within the firm. Technical personnel assigned to particular technical jobs or technical offices create and facilitate the use of technical documentation.

In comparison to more advanced countries, a substantial proportion of technical know-how used in production remains uncodified. More than half the sample across all the countries (particularly small and medium firms) use no technical documentation whatsoever and have no technical offices in the firm devoted to learning (see, for example, Table 5.16 in the Zimbabwe country study and 6.15 in Kenya). Another one-third of the sample use very little technical documentation and have one or two technical offices or personnel. The remaining 20 percent of the sample with significant technical documentation are very large, foreign and domestic establishments. Even here the use of technical documentation is used only sparingly as a learning device in the firm because of the level of literacy of the shop floor staff in each country. To understand more about sources of learning in African firms, the case studies inquired about how firms organized the personnel they employed. For example, did firms have specific technical offices where staff were dedicated to specialized technical functions, such as product engineering, quality control, laboratory testing, R&D, and the like? Such a functional division of labor will, of course, only show up in larger firms where work is more specialized; but, in these larger companies, it is interesting to see whether they organize labor to focus on particular learning tasks.

In each of the countries, the most frequently observed technical office was the quality control laboratory (see Table 5.16 in Zimbabwe and Table 6.16 in Kenya). All the larger food companies have a laboratory dedicated to quality control, and sometimes to product design and experimentation. In Zimbabwe, and in some instances in Kenya, product design offices were also found. For example, 70 percent of the garments firms in Zimbabwe and 40 percent of the furniture makers had design offices. Only about 12 percent of the sample in Zimbabwe and 5 percent in Kenya had a dedicated R&D office, although, as just noted, quality control labs in the food industry often performed R&D tasks. However, since we do not have comparable data for the technical organization of firms in other countries, it is difficult to say whether African firms are at all abnormal in the way they organize labor to focus on particular learning tasks.

Use of Expatriate Personnel

Like scientists, engineers and technicians, another element of organizational human capital conducive to learning is the presence of expatriate personnel in the firm. Expatriate personnel are a way to import superior technological know-how and to enhance on-the-job training.

As Table 4.31 shows, the use of expatriate personnel is common in all the countries. Most times they are used as managers, production managers and technical experts. They are often very important in enterprise training activities. Firms in Kenya appear to employ the most expatriate staff. They are evident across all sectors, but particularly important in metal working. Zimbabwe's use of expatriate staff appears surprisingly low, especially considering the number of expatriates casually observed in most medium and large firms. We suspect that respondents may not have viewed some local residents as expatriates, even though they were not Zimbabwean citizens. But it may also be true that the Zimbabwean government made it difficult for firms to bring in expatriate staff and, as a result, there are fewer employed than there might be.

Not surprisingly, the hiring of expatriates is related to firm size in all countries. Also, on average, expatriate personnel were most often evenly split between managerial and technical assignments across the countries. This was also true across the sectors in each country, with the exception of metal working, where two-thirds of expatriates were employed in technical positions.

Table 4.31
Use of Expatriate Personnel in Zimbabwe, Kenya and Ghana
(by Firm Size and Sector — Percent)

Firm Size (No. of Employees)	*Zimbabwe*	*Kenya*	*Ghana*
<10	0	2	1.5
10-49	5.3	17	1.4
50-99	16.7	45	22.2
100-249	8.9	76	21.7
250+	20.9		
Sector			
Food Processing	12.2	23	4.9
Textile and Garments	10.3	25	2.6
Wood working	7.7	23	7.6
Metal working	8.1	40	8.3

Source: RPED Survey Data, 1992-93.

External Sources of Learning

In addition to technical efforts inside the firm, manufacturing enterprises also need access to external sources of learning to support and/or substitute for internal endeavors. In principal, two types of external learning mechanisms can contribute to enterprise learning efforts: (i) *private mechanisms*, stemming from the firm's private business transactions with buyers and suppliers, and inter-firm spillovers of technical knowledge; and (ii) *collective mechanisms*, which derive from the activities of a collective of various institutions, like government, NGOs and business associations, to create an information-rich environment firms can learn from or to give direct technical support to specific firms.

External Private Mechanisms: Transactions with Buyers and Suppliers, and Inter-firm Linkages

Business transactions with (usually foreign) buyers and suppliers constitute one of the most important learning channels for African firms. The RPED case studies provide many examples of the transfer of ideas, skills and technical knowledge by way of business transactions. In Kenya and Zimbabwe, for example, the country studies note that a significant number of firms had undertaken some form of product modification in 1992, a few of which were major in scope. In Kenya, more than a quarter of these product development cases were based on customer-specified designs. In Ghana, foreign buyers, like Pier One Imports, are causing a revolution in handicrafts design and production, particularly among small producers (see Biggs and others 1994). And, in Zimbabwe, foreign buyers are assisting exporters to become more cost competitive and to reduce production turnaround times. Also, one large German buyer in the garments industry has a permanent expatriate staff member living in Zimbabwe for the sole purpose of working with local producers to upgrade quality and increase production efficiency (see Biggs and others 1995).

Suppliers are also helping to transfer technology. In Zimbabwe, for example, suppliers of equipment and other inputs are transferring skills and technical know-how by providing assistance in equipment purchase, installation and commissioning. About 40 percent of firms in the RPED survey stated that suppliers had provided training, supplied technical documentation for in-house learning, and assisted in troubleshooting and production planning. In Kenya, 42 percent of the survey firms acquired external assistance from suppliers to commission their physical plants. Suppliers either provided on-site services or trained company personnel to do the job. In Ghana, suppliers also played a role in training and installation of plant and equipment, but they were not as much in evidence as in Zimbabwe and Kenya. In addition, parent companies, joint venture partners and foreign investors also assist in technology transfer. Initial acquisition of technology, training and production planning were influenced by these agents in the case study firms.

Domestically, too, inter-firm spillovers of technological information are important external learning sources in most countries. Firms learn to be more competitive by "benchmarking" their activities with more efficient enterprises in the same industry. Firms also learn when they hire workers from more efficient rivals or receive training from larger sub-contractors. Unfortunately, RPED case studies indicate that domestic vertical and horizontal linkages between African firms are quite limited.

Part of the reason why vertical and horizontal linkages between firms are weak in Africa is that manufacturing activity is still relatively low, and, in most cases, activity that does exist was established under very uncompetitive circumstances. Three other contributing factors are: (i) the socioeconomic divisions which exist in society; (ii) the high transactions cost involved in these transactions and the inability of firms to exercise control over such relationships; as well as (iii) the degree of technological dualism that exists between the large and small firms in any industry.

The extent of imperfect competition exhibited in all the countries is relatively high. For example, in Zimbabwe, one study found that half of the manufacturing sector's 7,000 products are produced under monopolistic conditions, while 80 percent of the remaining products (40 percent of the total) are produced under oligopolistic conditions (see the Zimbabwe country study section). Under such conditions, vertical and horizontal linkages among subsidiaries of large, oligopolistic firms will exist, but there will be little competition and few linkages within market segments.

In both Kenya and Zimbabwe, parallel, non-intersecting information networks exist between the Asian and African communities and European and African communities, respectively. In both countries, Africans are engaged mostly in small business. Also, the African community, for historical reasons, generally possesses lower endowments of technical and engineering skills, on average. These factors make subcontracting between large and small businesses more costly, in terms of transaction costs and control, and in terms of the need for greater monitoring and technical assistance by the large procurer. In Ghana, the degree of technological dualism between firms also reduces the possibility of subcontracting and local procurement. As Table 7.13 of the Ghana country study shows, more than 80 percent of firms in all size classes had no subcontracting ties. In contrast, there does appear to be some evidence of diffusion of technological information among firms in Ghana, as indicated by the number of firms using other local firms as important sources of information in their acquisition of machinery and equipment. Both in terms of initial acquisition of machinery and equipment, as well as in acquiring new machinery and tools, almost a third of all microenterprises and a fourth of small firms cited other local firms as the major source of their information. Larger firms tend to rely on foreign sources of information.

Technical Assistance Contracts and Foreign Licenses

Two additional private external mechanisms firms use to access technology and information markets are technical assistance contracts and foreign technology licenses. The survey data in each of the countries indicate that the use of these learning mechanisms, however, are relatively infrequent.

Only 15 percent of the sample firms (29 firms) held foreign technology licenses in Zimbabwe, 5 percent (10 firms) in Kenya and 11 percent (20 firms) in Ghana. Most of the firms which purchased foreign technology licenses were larger companies in food processing or metal working (see Table 4.32). The average amount spent by a firm on these foreign licenses was approximately US$50,000 annually. A majority of firms holding licenses also had foreign equity or were foreign joint ventures. Along with the licenses, training and technical assistance was often included, but not in every case.

As for technical assistance contracts, only 13 percent of the Zimbabwe sample (27 firms) reported having a foreign assistance contract, 17 percent in Kenya (35 firms) and 10 percent in Ghana (20 firms). Again, most of these contracts are concentrated in large firms, many with foreign ownership shares, in the food processing and metal working sectors (see

Table 4.32) The average expenditures on such services in the companies with foreign assistance contracts was about 1 percent of sales.

Table 4.32
Use of Technical Assistance Contracts and Foreign Technology Licenses in Zimbabwe, Kenya and Ghana, by Firm Size and Sector
(Percent of Firms)

	Zimbabwe		*Kenya*		*Ghana*	
	Foreign License	*TA Contract*	*Foreign License*	*TA Contract*	*Foreign License*	*TA Contract*
Firm Size						
<10	0	2.3	0	0	1.5	0
11-49	0	2.6	4	2	4.1	1.4
50-99	6.7	3.3	10.5	16	16.7	11.1
100-249	13.3	15.6	6.5	21.7	21.7	13.1
>250	44.2	34.9				
Sector						
Food Processing	20.4	20.4	5.7	7.5	9.8	4.9
Textile and Garments	14.9	9.2	0	3.6	0	0
Wood working	0	7.7	3.3	6.7	5.7	1.9
Metal working	10.8	13.5	7.0	12.3	10.4	6.3

Source: RPED Survey Data, 1992-93.

External Collective Mechanisms: Technical Support Services

Technical support services are provided by a collective of service providers in Zimbabwe, Kenya and Ghana, ranging from government and NGOs to international donor agencies. The availability of such services can, in principle, create an information-rich environment of institutional and private sources of enterprise support for training, technical assistance and information, addressing specific business problems and assisting firms in upgrading their technical capabilities.

The demand for collective support services appears quite high in the three study countries. Ninety-three percent of survey respondents expressed interest in having additional support services available to the firm in all three countries. In terms of the specifics of this demand, firms were asked, in the case studies in Zimbabwe and Kenya, to indicate the particular services desired and then to rank the importance of the service to the firm.[51] The results are presented in Tables 4.33 and 4.34. The pattern of demand for specific collective support services has some distinct similarities across the countries. Employee training is at the top of everyone's wish list, together with productivity techniques (i.e., assistance with techniques to raise productivity). Quality control services were also in the top five in both countries. The focus of managers' training, productivity and quality control reflects the perceived need in these countries to adapt to a changing economic environment. This felt need is expressed even more forcefully in Zimbabwe by firms' desires for services to assist with process improvements and new product designs to become more competitive in the more outward-oriented economic setting. Only after these services were firms interested in such machine-oriented services as tools, dies and fixtures. However, repair and maintenance services appeared highly desirable on most wish lists.

Table 4.33
Zimbabwe — Highly Desired Support Services

	No. of Firms Interested	*No. of Firms Ranking It*	*Weighted Rank*
Productivity Techniques	28	25	2.97
Employee Training	24	22	2.51
Quality Control Testing	14	14	1.55
Process Improvement	19	14	1.51
Product Design	18	13	1.23
Repair and Maintenance	13	11	1.12
Troubleshooting Assistance	13	11	1.1
Energy Saving	12	8	0.83
Labor Relations	8	4	0.64
Pollution Control	7	5	0.46
Tools, Dies or Fixtures	7	4	0.43
Safety	5	4	0.33
Pilot Plant Experimentation	4	1	0.06
Instruments Calibration	2	0	0

Source: RPED Case Study, 1993.

[51] Specifically, firms were asked first to express their interest in particular support services — of the 35 firms questioned, the number interested is detailed the first column of Tables 4.33 and 4.34. Second, they were asked to rank the service in importance. Respondents were asked to choose the five most important services for their firms and then to rank-order them, giving a score of five to the most important and one to the least important. These scores were then weighted by the percentage of firms assigning a particular score. The number of firms ranking a service is presented in the second column of the tables. In the third column, the weighted average rank score of importance of each service is presented. The number of firms interested in a service can, of course, be different from the number of firms ranking a service, because some services will fall outside the top five of a particular firm even though the firm has an interest.

Table 4.34
Kenya — Highly Desired Support Services

	No. of Firms Interested	*No. of Firms Ranking It*	*Weighted Rank*
Employee Training	19	16	2.48
Repair and Maintenance	14	13	2.08
Productivity Techniques	14	13	1.95
Tools, Dies and Fixtures	15	11	1.68
Quality Control Testing	16	11	1.45
Troubleshooting Assistance	9	8	1.17
Labor Relations	9	6	0.92
Energy Saving	9	6	0.88
Safety	11	6	0.86
Process Improvement	10	5	0.60
Product Design	7	4	0.56
Pollution Control	5	2	0.30
Pilot Plant Experimentation	2	1	0.07
Instruments Calibration	6	0	0

Source: RPED Case Study, 1993.

The supply of collective technical support services in each of the three countries comes from several mechanisms. Compared with other parts of the world, such as Asia and Latin America, however, the number of collective services in the countries is rather meager. In Asia and Latin America, both centralized and decentralized providers, like business associations and in some cases foreign donors, offer numerous services (Levy and others 1994). In Africa, collective services provision is largely centralized — government is the largest provider (with donor support in some cases) — although NGOs and foreign donors are involved in some areas in the provision of more decentralized support services. Business associations and other types of industry-specific organizations, while they exist, deliver virtually no technology services to members. Nor do local governments deliver any business services as one might find in parts of Asia in specialized industry districts.

One way to judge the quality and coverage of centralized collective support services available in Zimbabwe, Kenya and Ghana is to observe the actual usage of the services by potential clients. Tables 4.35-4.37 present RPED survey data on the usage of centralized collective technical services. The first conclusion which can be drawn from the tables is the minimal use of collective technical support services in each country. The only service which is consistently utilized is the Bureau of Standards, mostly used by food processing and metal working firms. The second most-used services are those involved in training (unfortunately, in Zimbabwe, these were not included in the table). In terms of usage by firms size, in Ghana mostly small enterprises are using available services other than the Standards Bureau, and in Kenya it is large firms. On the whole, however, these figures clearly indicate low-intensity utilization of external collective support mechanisms in all three countries studied.

Table 4.35
Zimbabwe — Number of Firms Using Key Support Services by Sector, 1992

	Standards Assoc. of Zimbabwe	*Scientific & Industrial R&D Centre*	*Clothing Institute*	*Timber Advisory Board*	*Zimtrade*	*Assoc. of Packaging*	*Other*
Food	14	0	0	0	0	0	1
Textiles	4	0	3	0	3	1	3
Wood	3	0	0	2	0	0	0
Metal	10	4	0	0	0	3	4
Total	31	4	3	2	3	4	8

Note: 'Other' includes David Whitehead Laboratories, Overseas Institute, Dunlop, Engine Reconditioning Association, Motor Trading Association, and Leather Institute.

Source: RPED Survey Data, 1993. Sample of 200 firms.

Table 4.36
Kenya —Number of Firms Using Key Support Services by Firm Size and Sector, 1992

	Kenya Bureau of Standards	*Directorate of Industrial Training*	*Kenya Industrial Training Institute*	*Kenya Institute of Science and Tech.*	*Kenya Polytech.*	*Kenya Textile Training Institute*	*Kenya Industrial Research and Training Institute*	*Total*
Firm Size								
<10	5	0	0	0	1	0	0	6
11-50	17	6	2	1	0	0	1	27
51-100	16	7	2	0	1	2	0	28
101+	24	7	2	0	3	3	1	40
Total	62	20	6	1	5	5	2	101
Sector								
Food	25	5	0	0	2	0	1	33
Textiles	17	3	2	0	0	5	0	27
Wood.	4	7	1	1	0	0	0	13
Metal	16	5	3	0	3	0	1	28
Total	62	20	6	1	5	5	2	101

Source: RPED Survey Data, 1993. Sample Size is 223 firms.

Table 4.37
Ghana — Number of Firms Using Key Support Services in Panel Sample by Firm Size and Sector, 1991

	Food Research Institute	*Industrial Research Institute*	*Ghana Instrumentation Center*	*Ghana Standards Board*	*Kumasi Technical Univ.*	*Ghana Regional Appropriate Technology Industrial Services*	*Intermed. Technol. Transfer Unit*	*Total*
Firm Size								
≤10	6	6	6	7	5	7	6	43
11-50	6	3	3	17	7	5	2	43
51-100	0	1	1	6	1	1	1	11
101+	1	1	2	10	3	2	2	21
Total	13	11	12	40	16	15	11	118
Sector								
Food	4	2	2	16	2	2	3	31
Textile	3	3	4	7	4	3	2	26
Wood	3	3	3	6	5	3	3	26
Metal	3	3	3	11	5	7	3	35
Total	13	11	12	40	16	15	11	118

Source: RPED Survey Data, 1992. Sample Size is 179 firms.

The fact that most collective technical support services in Africa are provided by the centralized institutions of government is important in analyzing their low quantitative and qualitative impact on manufacturing activities in the economy. Even in East Asia, where government's track record in industrial policy is often praised, the record of centralized government provision of collective technical services is, at best, uneven (Levy and others 1994). The reason for this is that there is a vital need for institutions delivering broad based or high-intensity collective technical support to be close to and familiar with the needs of client groups. Centralized providers of all kinds of services, particularly in Africa, have a history of being disconnected from clients and lacking familiarity with their needs. In the area of collective high-intensity support, where the goal is to give larger, more technically sophisticated firm specific support, the problem of centralized provision is even greater. The collective agency supplying the support, for example a government technology institute, needs to have more competence on very specific problems (at quite sophisticated levels of technology) than do the firms themselves. Given government civil service pay scales and other such problems in Africa, it is almost impossible to staff centralized government institutions with the types of skills and competence required to organize and deliver such services.

Another central problem is the lack of cooperation between public and private providers of support services. This can be illustrated by focusing on the provision of the most highly desired collective support mechanisms in the surveys: work force training. Government in all three countries has supported vocational and firm-based training to varying degrees. Training taxes have been levied to pay for state-sponsored vocational education and apprenticeship programs in Ghana, Kenya and Zimbabwe. Also, government has been involved in qualification and certification of skills — for example, the Government of Zimbabwe has been heavily involved in classifying workers and certifying their skills, both as an instrument of employment policy and as an instrument of social policy to better the position of black African workers. State-sponsored unions have also been involved in training policy, particularly in Ghana and Zimbabwe. However, notwithstanding this direct involvement in support of in-service training, one cannot argue that it has been a great success.

Lack of public and private cooperation in training is a central problem in all three countries. Firm based training, training in vocational schools and privately provided courses in vocational schools and elsewhere require a degree of cooperation between business and government. Although some large private enterprises have managed high-quality in-house training programs in Africa, most firms need the help of outside training institutions. Similarly, for government vocational training institutions to be effective and market-oriented, they need to work closely with private business. Unfortunately, much of the interaction between business and government in the training area in all three countries has been adversarial. In Zimbabwe, for example, government has expected widespread commitment by industry to more training at all levels to prove its commitment to black African advancement. And, in all three countries, there has been political pressure for firms to absorb graduates from vocational schools while at the same time industry has been pushed aside from having a say in the organization and curriculum of training programs in these schools and kept out of debates on how training taxes are spent.

In all three countries, private sector sources have picked up some of the slack in meeting external training needs of firms. The most impressive example in Sub-Saharan Africa is Zimbabwe's large correspondence schools and growing network of private tutorial colleges and training centers. Zimbabwe has an extraordinary tradition of interest in professional and educational improvement (King 1990, pp. 15). But, these kinds of private training institutions also exist in Kenya and Ghana. But, here too, these private schools and the government have often been in conflict. The schools are sometimes characterized by the authorities as not offering quality programs, while the government is perceived by private trainers to be more concerned with control and regulation than with understanding private contributions to human capital development.

In concluding the discussion of the learning sources available to firms in Zimbabwe, Kenya and Ghana, one can broadly summarize the picture revealed as quite bleak, especially for most indigenous, African-owned firms. In general:

- With the exception of multinational companies and a few large exporters, most firms are technologically isolated from the rest of the world. As a consequence, connections with international private learning sources, such as foreign buyers and suppliers, are weak or non-existent. Zimbabwe and Kenya are somewhat better off in this respect because they have relatively large, local expatriate business communities (Asians in Kenya and Europeans in Zimbabwe), who have the advantage of being embedded in extended social and business networks via family and other connections which transcend national boundaries. Zimbabwe also benefits from its proximity to South Africa. The diffusion of benefits from these international connections, however, are constrained in Zimbabwe and Kenya by limited business interactions between the expatriate and indigenous communities.

- Most firms operate in an information-poor environment: (i) there are very few vertical and horizontal linkages between firms because large enterprises tend to be vertically integrated and there is very little subcontracting; (ii) direct foreign investment is limited, reducing the ability to "learn-by-copying" and the ability to "benchmark" the firm's operations against internationally competitive firms in the same business; (iii) training opportunities and specialized consultancy services are weak or non-existent locally, and expensive if imported; and (iv) information sources on technical and business matters are poor.
- Collective support services to assist and facilitate enterprise technical learning are often poorly delivered, when they exist at all. Business associations are also weak and deliver very few services, if any. NGOs and international development agencies provide some useful services, but coverage is limited and the support services are aimed at only a few areas, like finance.

With such poor external learning sources available to them, African firms are forced to rely almost exclusively on internal learning efforts to build their technical capabilities. By itself, this fact is not particularly problematical. For example, internal efforts have been identified as the most important source of technological capabilities amongst successful small-scale exporters in Asia and Latin America (See Levy and others (1994), Berry and Escandon (1994a,b)). The problem in Africa is that internal technical efforts of firms, with the exception of a few large multinationals, appear to be less than what is needed, limited in scope and sporadic rather than continuous. Moreover, without the availability of adequate external learning channels to increase the inflow of new know-how, internal learning activities can not go very far in upgrading skills towards internationally comparable levels.

5. Technological Capabilities and Learning Mechanisms: Zimbabwe

Background to Technology Development

Zimbabwe is often recognized as one of Sub-Saharan Africa's industrial leaders.[52] Its manufacturing sector today contributes approximately 29 percent of Gross Domestic Product (GDP) at factor costs, more than twice the average for the region. It produces an impressive array of diversified products. Its exports include a large component (more than a third) of manufactured items, decidedly uncharacteristic of the Sub-Saharan region.[53] And it is home of some of Africa's largest enterprises, such as Anglo American, Rio Tinto and the Delta Corporation.

Zimbabwe's pre-eminence in manufacturing in Sub-Saharan Africa has been conditioned by its factor endowments and political history. During Zimbabwe's colonial period, which ended in 1963, economic development was mainly geared to the exploitation of natural resources for exports. The large-scale commercial agriculture developed by white settlers in this period led to the development of complementary agro-industries, and created a market for manufactured products, mostly oriented toward the higher-income settler community, but also for lower-income black Africans living on communal lands. World War II scarcities created the second impetus for the installation of manufacturing capacity. In the late 1940s, a number of manufacturing plants were installed as a response to local shortages, generally by white immigrants or their children. The local black community at the time had neither the skills nor the financing to invest in industry. The third, and probably most important, impetus for manufacturing growth was the Unilateral Declaration of Independence (UDI) in 1963, and the resulting international blockade on Rhodesia.

During UDI, the government imposed strict market controls and regulations similar to those in wartime economies. Foreign exchange was controlled, competition was sacrificed to avoid duplication, and investment as a share of GDP was forced up from about 16 percent in 1965 to 29 percent in 1975. These policies and the external blockade provided a very strong set of incentives for the development of all sorts of local manufacturing businesses. From 1964 to independence in 1980, manufacturing production by volume grew at a compound annual rate of 5.5 percent. It has been estimated that over this period manufacturing diversified into 7,000 different product areas, compared to the 1,000 products it had been producing at the beginning of UDI (Riddell and Coughlin 1990). In many ways, this experience was similar to that of Latin America during the periods of forced import-substitution industrialization, which took place at the time of the Great Depression and World War II. By 1969, manufacturing already had become one of the largest economic sectors,

[52] This chapter is based upon results of field work conducted in Zimbabwe in 1993, and an internal report prepared for RPED as "From Autarkic Import Substitution to Exports: Technology and Skills in Zimbabwe's Manufacturing" in 1994, by RPED consultants Simon Teitel and Francisco Thomi, as well as their collaborators, Moses Tekere and Takawira Mumvuma of the University of Zimbabwe.
[53] Textiles and clothing, machines and transport equipment account for about 10 percent of exports.

contributing 19 percent of GDP. This expansion continued and by 1980 the share had risen to 24.9 percent. During UDI, textiles and metal products had the fastest growth (7.5 percent and 7.3 percent, respectively). Clothing and footwear grew at 3.1 percent, while transportation grew at about 1 percent. These growth rates reflected the country's need to substitute for imports of spare parts, simple metal consumer products and fabrics, while things like clothing, already being produced to some degree locally, simply grew to keep up with increases in population.

The heavy emphasis on import substitution industrialization towards the end of UDI ultimately began to show the negative effects that we have come to expect from such policy regimes in small markets — rising inefficiencies and declining growth rates. But there were also positive effects, not the least of which was the acquisition of a good deal of technical production capability in troubleshooting and repair skills to modify and adapt machinery, and to replicate imported spare parts. A substantial amount of self-reliance and learning took place during UDI in a number of manufacturing industries and, in many cases, the successful exporters of today learned to produce by first supplying the domestic market under the blockade. However, without access to more advanced R & D, most producers could not easily progress up to world market standards. Also, scarcity educated the market to accept whatever local industry could produce. Availability, not quality, was the main consideration. With such limited competition, producers had little incentive to upgrade productivity to world market standards.

In the final years of UDI, the growing problems of heavy import substitution were compounded by Mozambique's closing off access to its ports and by rising oil prices. Zimbabwe's terms of trade in the period 1975 to 1979 declined by 36 percent. During these five years, manufacturing production fell by 14 percent.

After independence in 1980, the pattern of manufacturing development changed somewhat. The new government had a strong socialist bent and put more emphasis on indigenous black development and state intervention in the economy. UDI regulations served the new government well, and most were kept in place together with an added focus on the parastatal sector.

In the first two years after independence, the economy enjoyed remarkable growth. Real GDP increased by 11 percent in 1980 and by 13 percent the following year. Several things were responsible for the rapid recovery. First, lifting of the blockade produced a sharp, once and for all, increase in exports. Second, foreign exchange controls were relaxed somewhat and production, particularly in manufacturing, benefited from increased access to imported intermediate materials and machinery. Third, government expenditures were increased substantially to rehabilitate infrastructure and to expand health care and education. Lastly, good weather and high prices resulted in a bumper crop in 1981. But these high growth rates could not be sustained. Expanding imports were not being met with equivalent increases in exports to pay for them. Rapid increases in government spending resulted in large budget deficits (about 12 percent of GDP), which fueled inflation. And the easy stages of import substitution were rapidly being exhausted, slowing growth.

To address this deteriorating economic performance, the government initiated a stabilization program in 1982. Monetary policy was tightened, a general wage freeze was announced, taxes were increased, prices of some commodities were controlled, and cutbacks in foreign exchange allocations were introduced. These measures drove Zimbabwe into a recession, which was aggravated by one of the worst droughts on record. By 1985, however, the external balance was restored, agriculture recovered from drought, exports increased and manufacturing started to grow slowly after a sharp decline. The only unresolved issue, which would continue to plague the economy for the remainder of the decade, was the government budget deficit, which was averaging about 10 percent of GDP, largely due to the government's continued expenditures on health, education, drought relief efforts, and the growing problem of subsidies to parastatals.

Throughout the remainder of the decade, the economy fluctuated as a result of drought, government deficits and additional efforts at stabilization. By 1990, it had become clear to government that economic performance over the first decade of independence had not measured up to expectations. Indeed, if one excludes the first two years of independence, GDP had grown only about 2 percent per annum, which was 1 percent less than the rate of population growth. Also, gross fixed investment in manufacturing over the period, particularly between 1982 and 1987, had declined steadily. It was becoming increasingly evident that policy uncertainty associated with government deficits, high costs associated with the foreign exchange allocation system (which was influencing access to capital goods, raw materials and spare parts) and the highly regulated business environment were all reducing business investment and slowing growth. This convinced government that more fundamental reforms were necessary. In 1991, therefore, Zimbabwe embarked upon a program of structural economic reform through the Economic Reform Program (ERP).

The ERP's overall aim was to liberalize markets and to decrease the role of the state. It eliminates the foreign exchange allocation system, liberalizes foreign investment rules and reduces the government deficit. Subsidies to parastatals and their monopoly rights are curtailed and price controls are eliminated, except for a few basic foodstuffs. Restrictions on hiring and firing of labor are also removed. Direct monetary controls on interest rates are eliminated. Business regulations are also revised to allow unfettered entry and exit. Lastly, trade liberalization reduces the vast array of tariffs and eliminate quantitative restrictions on imports. Social measures are also introduced to reduce the reform program's impact on the poor and those who have lost jobs.

Unfortunately, shortly after the government began to implement the ERP, Zimbabwe was hit with one of the worst droughts of the century. The negative effects on growth, however, did not cause the government to deviate from the scheduled policy reforms. As the economy begins to emerge from the influence of drought, empirical evidence is beginning to indicate that ERP is having the desired effect.[54] Gross fixed investment in manufacturing is increasing, resources are shifting from the non-tradable sectors to the tradable sectors, and

[54] RPED Survey Data, 1993 and 1994.

capacity utilization is rising. Manufacturing surveys also find that entrepreneur's expectations about future business conditions are bullish. However, there are signs that investment is being constrained by uncertainty about interest rates and access to finance.

Structure and Conduct of Manufacturing

Composition of Output and the Size Distribution of Enterprises

Although characterized by a concentration relatively simple low-skill activities, as noted earlier, the structure of manufacturing in Zimbabwe today exhibits a greater degree of diversification than other countries in Sub-Saharan Africa. The core of Zimbabwe manufacturing is in metal working, food processing, and textile production. As illustrated in Table 5.1, the metal working industry employs about 25 percent of the manufacturing labor force and contributes 27 percent of manufacturing value-added. Second to metals, the food industry contributes about 22 percent of manufacturing value-added, followed by the textile sector, which accounts for 17 percent. The wood working industry, based on the nation's forests which occupy 62 percent of the land, contributes about 11 percent of manufacturing value.

In terms of investment, the food processing sector accounts for the largest share of investment (37 percent) in manufacturing. The metal working, textile and wood working sub-sectors each contribute between 14 and 19 percent of total investment. The textile and food processing sub-sectors account for the bulk of manufacturing investment in plant and equipment. The public sector invests directly in manufacturing. Zimbabwe Iron and Steel Corporation and the National Oil Company of Zimbabwe are the largest public enterprises in industry.

Table 5.1
Zimbabwe — Sectoral Share of Manufacturing, 1991

Sector	*Value-added (%)*	*Investment (%)*	*Labor (%)*
Food and Beverage	21.8	36.7	20.8
Metal working	27.3	15.8	24.3
Textiles and Garments	16.7	18.9	24.3
Wood working	10.7	14.2	10.0
All others	23.5	14.4	20.6

Source: World Bank, 1994b. "Zimbabwe Country Economic Memorandum." Internal Document. Africa Region, Washington, DC.

Because of the country's industrialization history, market orientation continues to be focused on domestic demand, although the proportion of manufactured exports from Zimbabwe is greater than in other countries in Sub-Saharan Africa. As illustrated in Table

5.2, 26 percent of Zimbabwe's exports are manufactured goods. Metal working and textiles account for over 80 percent of manufactured exports.

Table 5.2
Zimbabwe — Total and Manufactured Exports by Sector, 1992

	Percent
Total Exports	
Manufacturing	26.2
Minerals	23.1
Agriculture	34.5
Other	16.2
Manufactured Exports	
Metals	46.3
Textiles	37.9
Machinery & Equipment	9.1
Chemical	7.7

Source: Regional Program on Enterprise Development, 1993. "Zimbabwe Country Background Paper." Prepared for the World Bank, Africa Technical Department by the Economic and Social Institute, Free University of Amsterdam, The Netherlands.

Dualism

The size distribution of firms producing manufactured products in Zimbabwe is, as in other African countries, quite heterogeneous. It also exhibits a clear bifurcation or dualism between larger firms, formally registered with the authorities and paying taxes, and smaller firms operating "informally" outside official scrutiny. This dualism extends to very pronounced differences between black and white-owned firms. For example, black entrepreneurs generally own small and medium enterprises, particularly the so-called informal sector firms, and white entrepreneurs own the large, formal sector firms. These forms of dualism are rooted in the colonial period, when political and economic institutions were dominated by a small white minority. In agriculture, the white settlers occupied the better half of the usable land for large-scale commercial farming, leaving the other half as Reserves or Tribal Trust Lands. The consequences of this process can still be seen. Large-scale commercial farming is practiced by some 4,000 (mainly white) farmers, employing about 150,000 workers, most of them black. About 75 percent of Zimbabwe's 10.4 million people live and farm in the Communal Areas, the formal Tribal Trust Lands.

When industrialization started, there was already a separate white dominating class that used its political power to support settler interests. Access to capital, as well as to higher education and management, was confined to "Europeans". State investments (e.g., in a steel company and in a cotton ginnery) provided a stimulus as suppliers of raw materials to manufacturers. The black population in the Reserves was used as a cheap source of labor. When they moved to town to work, they were not allowed to live in the same areas as the whites. While such restrictions no longer exist, very few black people can afford to live in the so-called low-density areas in the cities. There was an active policy to prevent the development of shanty towns. Zoning regulations were (and still are) strict and did not allow income-generating activities in the high density areas of towns. The black urban population depended therefore on employment in the white-dominated formal sector. As zoning and licensing regulations are now progressively relaxed, an urban informal sector is developing.

Concentration and Ownership

The manufacturing sector exhibits a high degree of firm concentration. Market structures tend to be either monopolistic or oligopolistic. Half of the manufacturing sector's 7,000 products are produced under monopolistic conditions while 80 percent of the remaining products (40 percent of total) are produced under oligopolistic conditions (UNIDO 1985). A recent report by the Zimbabwe Monopolies Commission (1992) revealed that 69 percent of Zimbabwean manufacturing originates in industries where the four largest enterprises account for at least 80 percent of gross output (calculated on the basis of Central Statistical Office data at the four-digit level).

There is disagreement on the extent of foreign ownership, reflecting the difference in definitions used. Since 1989, a firm has been considered foreign owned legally if 25 percent or more of its equity is foreign owned. Before 1989, the percentage was only 15 percent. By contrast, the Confederation of Zimbabwean Industries (CZI) considers a firm to be foreign owned if 50 percent of its equity is owned by foreigners. In 1989, CZI estimated foreign ownership to be 26 percent. Maya and Tongoona (1989) surveyed 667 companies and estimated foreign ownership to be 38 percent, of which 29 percent was by South African and British citizens. South African capital dominates the foodstuff, chemical, and furniture sub-sectors. Foreign ownership is particularly dominant in the furniture and clothing sub-sectors.

Enterprise Governance and Management

Manufacturing in Zimbabwe has a diversity of governance and managerial structures that reflect the country's social complexity. Most plants belong to white entrepreneurs, as noted previously. Others belong to foreign corporations. Parastatals grew after independence and some firms are legally registered as cooperatives.

In spite of the diversity of ownership systems, during UDI and after independence, all manufacturing plants have been subject to similar pressures and constraints, with the possible exception of differential access to foreign exchange which favored parastatal firms.

Managerial structures have been influenced by Zimbabwe's history. After independence, many mid-level white managers left the country, as did a large number of recently trained white young people. During the last fourteen years, the number of technical personnel graduated from the University of Zimbabwe and Harare Polytechnic has increased significantly. However, as yet, few have been incorporated into the managerial structures of large manufacturing firms.

Thus, one important characteristic of the organizational and managerial structures of many firms in Zimbabwe in the scarcity of black managers. There is no doubt that for the country's industry to be able to compete in a more open economy, it is necessary to develop black managerial skills, and to increase the number of black managers. One of the main policy challenges faced by the government is how to increase black participation in management without increasing state or party ownership of industry. In this respect, it has been useful to have had the experience of parastatal enterprises. Some parastatals are completely inefficient, but others, particularly those managed by the Reserve Bank, have been relatively efficient. These more efficient parastatals have made a significant contribution to black professional development by providing educated blacks employment in key managerial positions. Similarly, multinational companies have been important in providing opportunities for black managers. Many of the black entrepreneurs starting new firms today got their experience working for multinational firms.

Science and Technology

In 1985, Africa, excluding the Arab states, had one-tenth the number of scientists, engineers and technicians of Latin America and the Caribbean — 469,000 versus 4.75 million (UNESCO 1993, Table 5-1). On a per capita basis, the numbers were approximately 1.38 and 11.76 per thousand population, respectively. As to scientists and engineers engaged in R&D, Africa, again excluding the Arab states, had 0.7 percent of the world total number of scientists and engineers engaged in R&D in 1990, while Latin America and the Caribbean had 3.1 percent. In terms of R&D expenditures, Africa's share was 0.2 percent of the world total while Latin America and the Caribbean had 0.6 percent of the world total. As a proportion of Gross National Product (GNP) spent on R&D in 1990, Africa spent 0.29 percent while Latin America and the Caribbean spent 0.40 percent.

Zimbabwe is better off than most African countries in terms of educational attainment of its population, the number of trained scientists and engineers, and measurable outputs of scientific and technological activity. These endowments put Zimbabwe in a better position than other countries in the region to advance its future industrial technological frontier.

Educational Attainment

The educational attainment of Zimbabwe's population, as measured by school enrollments, has increased substantially in the last twenty years at all levels (Table A-1 in Appendix A.). The ratios of enrollments attained are far superior to the averages for Sub-Saharan Africa, and comparatively on a par with many Latin American and some Asian countries, particularly at the secondary level. Where Zimbabwe still lags behind the rest of the developing world is in tertiary education. Most Latin American countries have significantly higher enrollment rates at this level. One wonders, however, whether or not high tertiary enrollments matter much for industrial success when East Asia, the fastest growing region of the world, has only achieved regional average enrollment rates at the tertiary level equal to that of Zimbabwe.

Notwithstanding this expansion in general education, shortages of skilled manpower, particularly black technicians, continue to be reported by industry. The government has tried to address this problem by expanding vocational and technical training programs. Prior to independence, there were only two technical colleges. Since then, six more have been established. Total enrollment in these colleges jumped from 4,000 in 1980 to about 9,500 in 1990 (see Table 5.3).

Table 5.3
Zimbabwe — Total Enrollment at Technical Colleges, 1990

Type of Trade	*Enrollment*
Automotive	720
Civil Engineering	474
Electrical Engineering	718
Mechanical Engineering	886
Wood Technology	76
Printing and Graphic Arts	270
Science Technology	794
Business Education	4333
Computer Studies	234
Library and Information Science	109
Hotel Catering	147
Cooperatives	0
Mass Communication	575

Source: King K., 1990. "In-Service Training in Zimbabwe: An Analysis of Relationships Among Education and Training, Industry and State." Washington, DC: World Bank.

Before independence, black Zimbabweans had very limited opportunities to go through technical training, as such training was reserved mostly for white immigrants. Hence, an indigenous black skills base was never firmly established. Immigrants were encouraged to come from Britain and South Africa and take up strategic and skilled posts in industry. Many companies relied on on-the-job training to develop essential skills and black workers received some training through such ad-hoc programs.

Trade testing was introduced after independence to enable the recognition of acquired skills. Between 10,000–12,000 workers out of the 176,000 semi-skilled and roughly 500,000 unskilled formal sector employees have been upgraded and certified. The shortage of skilled labor is partly due to migration. Soon after independence, many skilled white workers left the country for South Africa. A few years later, this process was partially reversed and some whites came back to Zimbabwe because of the government's policy of reconciliation. However, in the late 1980s, the trend of emigration re-emerged and this time it included black skilled workers and professionals (engineers, artisans, technicians, accountants, etc.) who were seeking higher incomes in South Africa, Botswana and other neighboring countries.

This is partly the result of the high rates of taxation in Zimbabwe. The maximum tax rate currently stands at 55 percent, and it applies to incomes above Z$45,000 (US$5,625) per annum. In South Africa, an annual salary of R80,000 (US$20,000) per year is taxed at a fixed amount of R25,000, or 31.25 percent. Above this level, the marginal tax rate is 43 percent. In the case of Botswana, Lesotho, Namibia and Swaziland, the maximum tax rates are 40 percent, 53 percent, 42 percent and 40 percent, respectively.

The effect of this high income tax rate is reinforced by the relatively high cost of living in Zimbabwe. Housing, cars and consumer durables are much cheaper in neighboring countries to the south.

In 1990, it was estimated that the manufacturing sector had a shortage of up to 60,000 skilled artisans. The shortfall in respect to required engineering skills was estimated at 37 percent of what was needed. Part of the problem is a mismatch between the skill requirements of industry and the supply of skilled labor, particularly from the University of Zimbabwe. University intake is much higher in the field of social sciences than natural sciences. As a result, some graduates in the social sciences find it difficult to obtain employment.

There are now 8 technical colleges and 14 youth training centers in the country. In addition, there are private colleges and these contribute to the training of professional and technical manpower. The number of registered private colleges in 1990 was 108 and these on average produce some 12,000 graduates through managerial, secretarial, business, computer and other courses. Correspondence schools also provide a large number of courses in management, marketing and bookkeeping. The five schools (African Correspondence School, Rapid Results, International Correspondence School, Zimbabwe Distance Education College and Transworld Education College) currently enroll about 200,000 students.

According to the five-year National Plan (1991-1995), the government intends to consolidate existing technical colleges and training institutions in order to achieve full capacity utilization within the plan period. The government also intends to standardize technical and vocational education through a certificate structure in order to streamline the courses offered by private institutions, parastatals, local authorities, and government technical institutions. There will be five certificates: pre-vocational certificate, national foundation certificate, national certificate, national diploma, and higher national diploma.

In addition to the private and government training programs, multilateral donors and NGOs sponsor a number of training courses. The subject matter of these programs ranges from adult and youth education in business management and language to industry-specific courses in dress-making, blacksmithing, tool-making and carpentry.

Scientific and Technical Activity

Because of data limitations, it is difficult to quantitatively assess the outputs of scientific and technical activity in Zimbabwe. However, there are some available indicators which permit at least a rough comparison with other countries. Two available indicators are the number of patents granted and the number of scientific papers published in the international literature.

Available evidence on the number of patents granted to residents and non-residents in Zimbabwe and other African countries from 1960 to 1982 is shown in Table A-6 in Appendix A. Table A-7 in Appendix A shows similar data, on a per capita basis, for 1985 for Zimbabwe and other developing countries. Several conclusions follow from these data:

- The output of industrial research, in terms of patents granted, is quite low in Sub-Saharan African countries, including Zimbabwe.[55]
- Moreover, all countries included, except Kenya, have a lower yearly average number of patents granted recently than during the historic period (generally from the early 1960s to 1982).
- The vast majority of the patents are granted to non-residents, thus not representing industrial research activity carried out in the country. Even those granted to residents could belong to subsidiaries of multinational corporations (MNCs).
- On a per capita basis, for total number of patents, Zimbabwe compares favorably with other relatively poor countries in Asia and Latin America, although the extremely low proportion of patents granted to residents should be noted.

The production of scientific literature represents, potentially, another useful indicator of scientific and technological activity. Data on scientific papers published is however scarce, and particularly so for African and other developing countries. Nevertheless, data on some African countries has been made available recently and is reflected in Tables A-4 and A-5 in Appendix A.

The total output of published scientific papers from Sub-Saharan Africa amounts to approximately 0.5 percent of world output. This compares unfavorably with its share of world population (9.1 percent) and GDP (0.76 percent). Latin America, which is responsible for about 1.1 percent of world scientific output (Inter-American Development Bank 1988,

[55] For example, in 1980, 10 Latin American countries had each more than 100 patents granted with 3 of them having more than 1,000. For these countries, the average (non-weighted) proportion of patents granted to residents was 11 percent (Inter-American Development Bank 1988, Table H-4).

Table IX-1), accounts for only 8.5 percent of world population, but has a larger share of world GDP (5.6 percent) than Sub-Saharan Africa.

These data show that African research publications are concentrated in a few countries. The two major producers account for more than 60 percent of total output from Sub-Saharan Africa, and six countries are responsible for three-fourths of the total. Zimbabwe's share of 4 percent is somewhat above its share of both GDP (3.3 percent) and population (2.06 percent) in Sub-Saharan Africa.

Table A-5 in Appendix A shows the distribution of research papers by field for selected Sub-Saharan African countries, including Zimbabwe, and also indicates how this distribution compares with those corresponding to Latin America and the world. As can be seen, the field distribution of research publications in Sub-Saharan African countries is quite lopsided when compared to that of the world or Latin American countries. There is a strong bias towards publications in clinical medicine and biology to the particular detriment of chemistry, physics, engineering and technology. In the case of Zimbabwe, this tendency is particularly strong with respect to biology, where publications constitute 50 percent of all research publications. On the other hand, although the country's absolute number of papers is very small, it almost matches the world average share of papers in clinical medicine and mathematics.

Characteristics of the Survey Data

The field investigations, on which this Zimbabwe technology study is based, were carried out in June 1993 (the survey) and late October-November 1993 (the enterprise case studies). As noted earlier, the case studies involved interviews of a pre-selected sub-sample of manufacturing establishments previously interviewed in a large survey using a pre-designed and tested questionnaire. The case studies also included visits to selected industrial technology support institutions.

The case study interviews were arranged by local counterparts from the University of Zimbabwe, Messrs. Moses Tekere and Takawira Mumvuma, both of whom are lecturers in the Economics Department. Three-fourths of the interviews were programmed for enterprises located in Harare and its suburbs, and one-fourth for firms in the city of Bulawayo. In all cases, the interviewing team included an international and a local consultant.

A total of 41 firm interviews were carried out in the case studies: 31 in Harare and ten in Bulawayo. Large firms (with employment greater than 100 employees) were somewhat over-represented, while smaller firms were under-represented among the enterprises actually interviewed. In addition, the following technology institutions were visited: Standards Association of Zimbabwe, Harare Polytechnic, Faculty of Engineering at the University of Zimbabwe, Zimbabwe Institute of Engineers, Small Enterprise

Development Corporation (SEDCO), Scientific and Industrial Research and Development Center (SIRDC) and Zimbabwe Investment Centre (ZIC).

The survey of 200 randomly selected, large and small manufacturing firms was carried out by researchers from the Free University of Amsterdam in conjunctions with researchers from the University of Zimbabwe. The questionnaire was designed by the World Bank. The survey included firms in Harare, Bulawayo and other locations.

The Sample

The case study sample of 41 firms, as already noted, was selected from the 200 firms included in a larger panel survey, which was carried out a few months earlier. We attempted to make the sample representative of the existing industry composition, location, size, ownership structure and ethnic background. The case study sample included 13 firms (31.7 percent) from the food and beverages industry, 10 firms each (24.4 percent each) from the textile and garments and wood and furniture industries, and 8 firms (19.5 percent) from the metal working industry. Table 5.4 shows the contrast with the panel sample. The composition of the panel (larger sample) seems quite lopsided since 44 percent of all the firms are from the textile and garments industry. The case study sample is somewhat under-represented in metal working (8 firms) and over-represented in food and beverages (13 firms).

Table 5.4
Zimbabwe — Industry Composition
(Comparison of Case Study and Survey Samples)

	Food		*Textile*		*Wood*		*Metal-working*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	13	31.7	10	24.4	10	24.4	8	19.5	41	100
Survey	48	24.0	88	44.0	26	13.0	37	18.5	200	100

Source: RPED Survey and Case Study Data, 1993.

The sectoral distribution of firms in both samples does not necessarily correspond to the industrial composition of the manufacturing sector. According to the 1989 Census, food, beverages and tobacco accounted for 30 percent of manufacturing output, clothing and footwear for 18 percent, wood and furniture for 3 percent, and metals, metal products and transport equipment for 24 percent.

As already noted, 31of the firms interviewed for the technology study were located in Harare and its surroundings. The remaining 10 firms were located in the Bulawayo area. These two cities and their suburbs account for approximately three-fourths of the country's manufacturing output. In Table 5.5, the location distribution of the firms in both samples are compared. The survey sample also includes 32 firms (16 percent) which are not located in either of these two main centers.

Table 5.5
Zimbabwe — Location Distribution of Firms in Both Samples

	Harare		*Bulawayo*		*Other*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	31	75.6	10	24.4	0	0	41	100
Survey	114	57.0	54	27.0	32	16.0	200	100

Source: RPED Survey and Case Study Data, 1993.

The size classification was adjusted in Zimbabwe to reflect its relatively more developed manufacturing sector compared to other countries in Sub-Saharan Africa (i.e., Ghana and Kenya), which results, among other things, in a larger average size of firm and a greater number of "large" firms. Thus, firms were classified as follows: small (those employing up to 10 workers); medium (employing between 11 and 100 workers); and large (employing more than 100 workers). In Table 5.6, the size composition of both samples is shown. In both samples, the "large" sub-sector is over-represented, but a bit more so in the case study sample, where the number of "small" firms is quite restricted. The reason for the over-representation of large is that the survey sample was drawn by employment, not by number of firms within size groups.

Table 5.6
Zimbabwe — Comparison of the Size Composition of Both Samples

	Small		*Medium*		*Large*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	4	9.8	14	34.1	23	56.1	41	100
Survey	43	21.5	66	33.0	91	45.5	200	100

Note: Small = Firms employing up to 10 workers.
Medium = Firms employing from 11 to 100 workers.
Large = Firms employing more than 100 workers.
Source: RPED Survey and Case Study Data, 1993.

In the technology sample, 29 firms are private and locally owned, 2 firms are private under foreign ownership, 3 firms are private joint ventures with foreigners, 5 firms are joint ventures between the state and foreigners, 1 firm is a joint venture between the state and local private owners and 1 firm is a joint venture between the state and foreign private owners. In Table 5.7, the ownership structure of both samples is compared. The composition is quite similar, with a slight over-representation of the state sector in the technology sample, and conversely in the survey sample.

Table 5.7
Zimbabwe — Ownership Structure, Comparison of Both Samples

	Private (Z)		*Private (F)*		*Private (Z&F)*		*State & Private (Z)*		*State and Private (F)*[a]		*State*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	29	70.7	2	4.9	3	7.3	1	2.4	5	12.2	1	2.4	41	100
Survey	153	76.9	15	7.5	19	9.5	3	1.5	7	3.5	2	1.0	199	100

[a]Panel figure includes one State and Private (Zimbabwean and Foreign).
Notes: Z = Zimbabwean; F = Foreign.
The survey total reflects one missing firm for which the ownership was not recorded.
Source: RPED Survey and Case Study Data, 1993.

Table 5.8 shows the ethnic origin of the firms in the case study and survey samples. The table shows that more than half of the firms for which data were available in the case study sample were owned by Europeans, or people with European ethnic background, while only about 17 percent were owned by Africans. The survey sample did not show as large a difference, with about 46 percent of the firms with data available being owned by Europeans and nearly 33 percent by Africans.

Table 5.8
Zimbabwe — Ethnic Background of Firm Owners

		Asian		*European*		*African*		*Other*[a]		
Sector	*Sample*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*Total*
Food	Case Study	1	8.3	7	58.3	1	8.3	3	25.0	12
	Survey	3	13.6	21	26.3	10	17.5	5	35.7	39
Textile	Case Study	1	11.1	5	55.5	3	33.3	0	0	9
	Survey	14	63.6	35	43.8	30	52.6	3	21.4	82
Wood	Case Study	0	0	6	75.0	2	25.0	0	0	8
	Survey	2	9.1	10	12.5	9	15.8	2	14.3	23
Metal	Case Study	0	0	4	57.1	0	0	3	42.8	7
	Survey	3	13.6	14	7.5	8	14.0	4	28.6	29
Total	Case Study	2	5.5	22	61.1	6	16.7	6	16.7	36
	Survey	22	12.7	80	46.2	57	32.9	14	8.1	173

[a]Includes firms with mixed background, public corporations and state firms in the case study sample.

Note: For 5 of the firms from the technology sample and 28 firms from the survey sample, the racial origin of the firms could not be established due to the legal status of the firm (subsidiary of a Zimbabwean or multinational firm), because it was considered too sensitive to ask (the owner was not interviewed), or because it was not applicable (cooperatives, state-owned enterprises).

Source: RPED Survey and Case Study Data, 1993.

Technological Capabilities and Learning Mechanisms: A Summary Evaluation

Investment Mechanisms

Since the late 1980s, the observed rate of gross domestic investment has increased substantially in Zimbabwe, reaching its peak in 1991, shortly after the introduction of the ERP. Figure 5.1 highlights this growth in investment at the aggregate level. The decline in investment in recent years can be attributed to the severe drought and high interest rates caused by the government deficit.

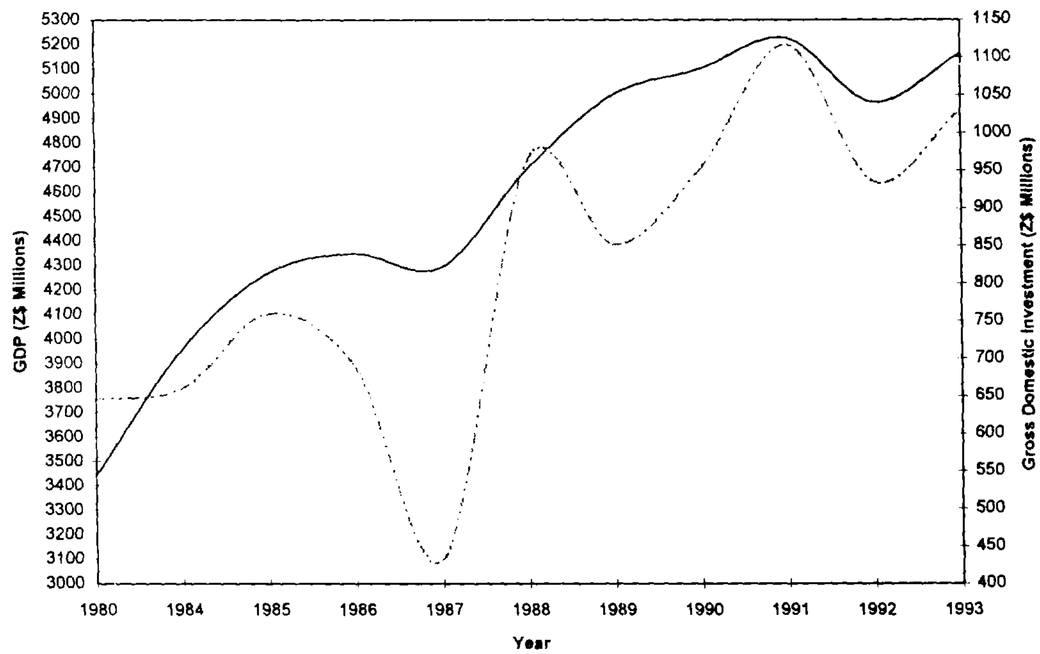
At the level of the firm, this trend is borne out by the RPED enterprise survey. Of the 200 firms interviewed in 1993, 77 percent responded that they had made major investments in the last three years. If we look at the longer five-year horizon since 1989, this figure rises to 85 percent of the firms (see the survey results in Table 5.9). As the figures indicate, firms in all size classes have been making investments in the past five years. In terms of the magnitude of investment, it is the large enterprises in each industry which drive the aggregate trend. For example, ninety-one percent of firms with more than 250 employees have made investments equal to 16 percent of the replacement cost of capital. But small companies are also playing a part — the 10 to 49 size class made investments in the last five years equal to 28 percent of replacement cost of existing capital stock.

Most of this manufacturing investment in the early 1990s, in terms of value, was taking place in the food (31 percent of cost of capital), wood working (14 percent), and textile and garments (16 percent) industries.

In the majority of cases, firms are investing to add to productive capacity (about 43 percent across all size classes) or to improve production processes (about 25 percent). For 67 percent of the largest firms, these investments have resulted in lower production costs. Large firms also report (not shown in Table 5.9) that in more than 80 percent of the cases, these investments have resulted in increased product quality. In the cases where costs of production have reportedly risen as a result of the investment (39 percent of the 100-249 employee size class cases), product quality has also increased significantly.

The outcome of all this investment effort depends critically on enterprise investment capabilities. As noted in the conceptual framework for this study, investment capabilities include the skills and information needed to identify feasible investments, search for suitable production technologies, adapt and install new equipment and solve technical start-up problems. If these firm-specific capabilities are low, then the returns to investment may be reduced. Firm-level technology case studies and responses to the larger survey of enterprises help to focus on this issue. The problem of acquiring appropriate technologies in Zimbabwe is examined first.

Figure 5.1
Zimbabwe —Real GDP and Gross Domestic Investment



Note: Figures are in constant Zimbabwe Dollars (Base Year = 1980 = 100).
Source: World Bank. Bank Economic and Statistical Database. As of March 27, 1995.

Acquisition of Technology

Initial Acquisition for Start-up. The need for sophisticated investment capabilities in starting up a firm will depend upon the size and complexity of the investment. Small firms in simple, labor-intensive activities, such as garments and furniture-making, have relatively low entry requirements in this respect. Investment size is relatively small and technologies in use are relatively simple. On the other hand, larger firms in more complex, capital-intensive activities, such as fabrication of metal construction materials or machine tools, require a good deal of know-how in planning, searching for appropriate technologies and installing the equipment properly.

In general, Zimbabwe, like most African countries, produces a mix of products of relatively low complexity compared to the rest the world. However, within this product mix, technical complexity of production technologies varies substantially across industries and within industries across product segments and firm sizes. Therefore, an assessment of investment capabilities in Zimbabwe would expect to find: (i) on average, that technical sophistication of entrepreneurs, compared to more developed regions, is relatively low (because of the mix of products they produce); (ii) a great deal of heterogeneity in investment capability across industries and within industries across firm sizes; and (iii) an absence of well-developed private technical support services catering to a spectrum of users at low cost because of the small market size.

Origin of the Firm and Start-up Feasibility Studies. Many firms in Zimbabwe use old machinery. In a number of them, established over 25 years ago, there is no institutional memory and current management does not know much about the firm's origin, except vague facts, such as "it began as a small operation." Other firms, mainly the newer ones, recall their origins. Indeed, 22 of the 41 firms in the case study sample stated that they began as small operations under current ownership; 12 were acquired as ongoing concerns by current owners (most of the current owners believed that these also began as very small operations); only 4 started as full scale plants (1 of these was a joint venture). Three plants did not provide any information about their origin.

All of the entrepreneurs who started firms had production experience in their fields and had worked in the industry in which the business was started. In most cases, no feasibility studies were carried out before starting the business; about 90 percent of the plants surveyed reported no such studies. Many entrepreneurs stated they had no available information before starting up except their own experience. Among the few firms that had done feasibility studies (mostly large enterprises), two were done by the entrepreneur himself, two by in-house personnel, and two by the foreign partner. No firm reported having any assistance from outside the firm or its partners in undertaking feasibility studies (e.g., hired consultants, public donor, or NGO support services).

In some cases the entrepreneurs "followed their intuition," and in others, they simply felt that they knew the business well enough to be able to succeed without a formal evaluation of their investment. It should be noted that several firms with large fixed capital investments were established to use large domestic input supplies that would have been wasted otherwise, such as milk and pork. In these cases, the manufacturing plants were created to meet what were very well-known demands of specific lobbies, and there was no critical need to do a formal project appraisal. In cases where firms had changed hands since they were established, buyers had said that project evaluation studies were made at the time of purchase.

During our case study investigations, we also visited the venture capital company of Zimbabwe to inquire about their methods for assessing venture capital start-ups. In the cases of the twenty new black-owned companies we reviewed, very detailed feasibility studies had been done. Each of these firms had been started in the last three years, and were in the small to medium size categories. They were being managed by well-educated, experienced entrepreneurs who had worked for large domestic or multinational firms. Many entrepreneurs had experience in the industries in which the new company operated and generally had either a technical or financial background.

Table 5.9
Zimbabwe — Attributes of Major Investments
(Percent of Firms)

Firm Size	*Year of Investment*			*1990-93 Investment/ Capital Stock*	*Purpose of Investment*						*Technical Adaptation*	*Cost Change*		
	0-5	5-10	>10	Mean Value	1	2	3	4	5	6		Higher	Same	Lower
<10	83	11	6	17	28	40	17	0	8	6	8	28	32	39
10-49	81	11	8	28	27	38	15	0	15	4	4	23	45	32
50-99	78	18	4	11	26	52	7	0	11	4	11	13	35	52
100-249	90	8	2	13	15	41	18	2	18	5	21	39	35	26
250+	91	7	2	16	27	44	17	2	7	2	17	13	20	67

Note: Year of investment = 0-5 means in the last five years; 5-10 means in the last 5-10 years, and >10 means more than 10 years.

Investment/Capital Stock = Value of investment in the 1990-93 as a percent of replacement cost of capital stock.

Purpose of Investment: 1 = Produce the same product but improve process
2 = Produce the same product but add to capacity
3 = Introduce new products
4 = Produce a different variety of a similar product
5 = Replace old equipment with similar equipment
6 = Other

Technical Adaptation = Firms that carried out technical adaptation to the equipment.

Cost Change = Impact of new equipment on cost of production of unit of output.

Source: RPED Survey Data, 1993. Total observations = 200 firms.

The choice of machinery and equipment to begin operations was most frequently made by the entrepreneur. Local or foreign consultants and foreign partners assisted in only 5 percent of the cases. In cases of subsequent expansions, the role of the entrepreneur declined somewhat. In most cases, in-house technical personnel and consultants played an important role. Also, entrepreneurs reported that, in expansion decisions, the availability of equipment on the local market was very important in machinery selection.

The choice among equipment types and specifications was often heavily influenced by way of interaction with equipment suppliers. But in 50 percent of the cases, entrepreneurs' familiarity with the production process also influenced the final decision. In the other half of the cases, various sources of information influenced events: international partners' preferences, information from technical journals, travel abroad to visit trade fairs, and interaction with other firms in the business.

A different aspect of the selection issues is the example of firm--FP1401, the Zimbabwe franchisee of an international non-alcoholic beverage firm. Its franchise agreement stipulated that FP1401 purchase used equipment from the parent, which would appear to handicap the African firm. However, the machinery was received, reconditioned and successfully installed. The management of FP1401 has decided, on the basis of this experience, to restrict purchases of more advanced technologies to non-computerized equipment. In another case, six firms each contributed used equipment, most of which had previously been operated in South Africa, to create a new company. Subsequent additions have followed the same pattern. In yet another case, used equipment was brought from the UK to start the operation.

The pooling of used equipment reflects the investors' inability to gain government approval for their investment plans requiring the purchase of foreign exchange. The import of used equipment from a foreign, but related firm, located in South Africa, the UK or the US is a measure both of the parent firm's perception of the market opportunity and of the inability of the local affiliate to gain a foreign exchange allocation for new equipment in competition with parastatals. Used machinery may be a good financial ploy with bad operational results. One local affiliate of a multinational personal care products manufacturer had chronic problems with its used machinery. It managed to gain Zimbabwe government permission to import its new US-manufactured machinery after prolonged and high-level discussion, and then because the equipment was key to the manufacture of a product which the government had added to its own central economic priority planning list.

Used Machinery. The use of second-hand machinery at start-up has been very common in Zimbabwe, even in larger plants, reflecting the financial limitations and the tight foreign exchange constraints since 1965 (see Table 5.10). Used machinery is not, of itself, an indicator of insufficient technological capabilities. On the contrary, it may reflect an insightful investment strategy. There were cases during the early 1980s in which funding and foreign exchange was approved by the government to import used machines from the then COMECON countries at significantly lower prices than those for similar equipment made in the West or Far East.

Table 5.10
Zimbabwe — Initial Investments: Source and State of the Equipment Purchased
(Case Study Sample — Percent)

	Source of Equipment		*State of Equipment*	
Investment Time	*Foreign*	*Local*	*Used*	*New*
Start-up	84	16	76	24
Addition	87	13	28	72

Source: RPED Case Study Data, 1993.

Source of Equipment. Not surprisingly, machinery was purchased chiefly from countries with a strong machine tool and machine building industry. Thirty percent of the machinery (new and used) of the sampled firms comes 30 percent from the US and 19 percent from Germany. The 12 percent which originated in Zimbabwe reflects the relatively high level of metal fabrication development. Interestingly, the sample did not capture any instances of equipment produced in the former Council for Mutual Economic Assistance (COMECON) countries, which is known to have been installed chiefly in parastatal firms. Among the less-developed capital equipment producers, some Zimbabwean firms reported owning smaller pieces of equipment from Bulgaria, India and Taiwan. This anomaly is likely due to the relatively small number of parastatals included in the sample.

There are many examples among the case study firms of well-sourced purchases. Case study firm TF271, for instance, which started up 35 years ago with little more than 2 used sewing machines, now produces export quality garments with machinery all less than 15 years old and purchased new from Japan and Germany. Firm MW411 sourced new metal polishing machinery from its Spanish manufacturer with little difficulty other than access to foreign exchange.

Satisfaction with Present Equipment. It appears that the ERP has been a success in introducing the competition of new technologies into the market. Sixty-six percent of the firms saw the need to lower the costs and boost productivity, 59 percent saw the need to improve quality, 44 percent simply to improve productivity and 27 percent simply to increase output.

Zimbabwe's industry is in the market for change. Only 12 percent of firms were sufficiently satisfied with their present technological and production capacity that they would buy the same equipment they now have. Of the remainder, 39 percent of new firms would prefer a plant that would allow them to produce larger quantities with new technologies; 15 percent would like to retain the same productive capacity but employ newer technology; and 17 percent would like to produce larger quantities with the same technology. In 15 percent of the cases, the firms would like other types of equipment.

These results are reflective of the history of manufacturing in Zimbabwe, the policy changes currently being experienced and the expected changes in the international environment. It is clear that most firms would like to have a plant with equipment different from what they have. In some cases, the desired changes are small, for instance, a more versatile sewing machine, but in most, these changes are more drastic. There is a noticeable desire not just to lower costs and increase productivity, but also to improve quality. This is a significant departure from the past, when the main challenge for manufacturing entrepreneurs was production for the protected domestic market. As Zimbabwe's economy opens to international competition, cost reductions and quality improvements are being seen as indispensable for success.

However, the desire for new technology is not necessarily always for more advanced technology. In some cases, it reflects the needs imposed by the low level of training of the labor force. Managers frequently indicated that they want better and newer technologies, but they made it clear that they do not intend to employ up-to-date machines that require high skills to service and repair. In other cases, the reason for wanting newer technology was to "de-skill" the process of production. The desire was to have new machines so that workers' skills would have a lower impact on the quality of the final product.

Installing Equipment. Zimbabwean firms typically engage equipment suppliers to assist with installation and commissioning. The large food processor, FP1221 for instance, contracts specialists from Europe and South Africa for this purpose. FP1401's in-house personnel worked with the supplier to resolve start-up problems with a new bottling line.

Among the 30 plants where institutional memory encompassed the start-up phase, the most frequently cited start-up problem was equipment breakdown, consistent with the fact that used machinery and equipment was often purchased. Results indicate that the established Zimbabwean entrepreneurs sampled have generally been successful in debugging their plants. There seem to be enough mechanical skills present in the market to fix and maintain machinery. In all but four cases, the problems were resolved with in-house skills.

Whether these skills will be widely accessible to new black entrepreneurs is an entirely different question. Judging from the insularity of the ethnic groups, one might reasonably suggest that black entrepreneurs will be limited, for the most part, to the technological capabilities available within the sub-group with which they are identified.

While entrepreneurs have been able to successfully install and debug machinery and equipment after purchase, they seem to have made few adaptations to the imported technology. Case study interviews indicate that more than half of the firms felt adaptations or slight modifications of their imported machinery to better fit the local environment would enhance productivity. As Table 5.9 indicated, very few firms, however, seem to be able to make such adaptations in Zimbabwe. Making major modifications to equipment, as opposed to fixing or maintaining it, requires engineering capability and a reasonably sophisticated machine tool industry, both of which are underdeveloped in Zimbabwe. The data does show, however, that larger enterprises do appear to have more capability than smaller enterprises to do this type of re-engineering — on average only about 6 percent of firms with fewer than 50 employees report making any adaptations to purchased equipment. This rises to about 20 percent of firms with greater than 100 employees.

Production Capabilities

Production capabilities can be considered under two broad categories: process technologies and product technologies. Process technological capabilities include efficient plant design and layout of the production line, quality control, maintenance and industrial engineering. Product technological capabilities include improvements in product design or the introduction of new product designs. The acquisition of more than basic production capabilities generally requires considerable time and effort.

Process Technologies

Plant Layout. Efficient execution of a technology starts in the design of a production space and the layout of a production line. A process will be executed more efficiently to the degree that the space in which it takes place is suited to the process. Factory design and production line layout is the result of the entrepreneur's level of knowledge about the production process, exposure to peer-group best practices, as well as access to land and premises.

Plant facilities were adequate in most cases. Many of the buildings visited were clean, well-kept and the plants were well organized. However, in about 25 percent of the plants, deficiencies were found ranging from lack of basic infrastructure to crowding, bad layouts and disregard for safety and cleanliness. Major deficiencies were found in a few small enterprises that have not been able to accumulate significant amounts of capital and do not have access to credit. In these cases, the premises were not built for manufacturing, and tend to be quite crowded. The main safety problems were mainly related to lack of proper ventilation and of protection equipment or failure to use it.

Capacity utilization of plants was found to be varied. This is not surprising since the manufacturing sector is experiencing a significant adjustment due to changing domestic policies and external environment. According to management, about a quarter of the plants visited were operating at 50 percent capacity or less. About 30 percent of them operated at between 51 and 75 percent of capacity, 12 percent between 75 and 89 percent of capacity, and 32 percent at 90 percent of capacity or higher, as shown in Table 5.11.

Table 5.11
Zimbabwe — Distribution of Firms by Level of Capacity Utilization
(Case Study Sample)

Capacity Utilization	*Frequency*	*Percent*
Up to 50%	11	26.8
51–75%	12	29.3
76–89%	5	12.2
90–100%	13	31.7

Source: RPED Case Study Data, 1993.

Capacity utilization varied significantly by sectors. *Wood and furniture* was operating at very high levels. Eight of the ten plants visited were operating at 90 percent of capacity or higher. Indeed, seven were operating at full capacity. In *textiles and clothing*, the distribution was more even: three of nine plants ran at 90 percent of capacity or higher, two at 50 percent or less, three between 51 and 75 percent and two between 76 and 89 percent. *Food and beverages* had the lowest rates of capacity utilization: six of thirteen plants operated at 50 percent of capacity or less, and only two at 90 percent of capacity or higher. *Metal manufacturing* plants operated at between 40 and 85 percent of capacity. These differences reflect:

(i) the relative export success of the wood and furniture sector;

(ii) the problems of some food plants related to the decline in input supplies due to the recent drought and the increased competition from abroad;

(iii) the low levels of demand for machines, equipment and consumer durable goods produced by the metal manufacturing sector, due to the country's recession; and

(iv) the downsizing of some textile and other clothing plants whose exports have declined due to increasing costs and whose domestic demand shrunk because of the domestic recession.

One-shift operation was the norm in most plants. In cases where more than one shift was worked per day, the higher night wage and other costs exceeded the savings from using fixed capital more intensively. Of 35 reporting plants, only 6 operated more than one shift. However, even in those cases, only some sections and machines were operating more than one shift. Multiple-shift operation tended to be the result of unbalanced production processes or the need to respond to seasonal demand peaks. In several plants operating more than one shift, this was considered to be a temporary pattern, and measures were being taken to correct plant imbalances to operate only one shift in the future.

Process technologies also include the technical efforts necessary to maintain and troubleshoot physical plant and equipment, as well as efforts to control the quality of goods produced. Zimbabwean firms perform both these tasks, although the amount of effort varies by sector and firm size.

Maintenance and Troubleshooting. Zimbabwean firms have learned from necessity to be self-sufficient in order to maintain the physical plant. As seen in Table 5.12, the breakdown of equipment has become so routine as to be integrated into the production process to the point that the main task of the plant manager is to deal with breakdowns. Maintaining equipment at optimal operating efficiency is not an option, but is critical to keeping it running with a minimum of interruptions and production downtime. Well organized manufacturing establishments try to avoid surprises, including lengthy waits for spare parts, by scheduling maintenance activities to a substantial extent on a preventive basis, i.e., at fixed moments in time when the machines are still running without having experienced breakdowns or the need to repair parts.

Table 5.12
Zimbabwe — Frequency of Troubleshooting Problems Reported
(Proportion of Case Study Firms Citing Specific Problem; Multiple Answers Allowed)

Problem	*Frequency*	*Percent*
Equipment breakdown	31	75.6
Breakdowns in production process	13	31.7
Serious quality control problems	9	22.0
Pollution control problems	9	22.0
Safety/accidents	6	14.6
Others[a]	5	14.6

[a]Almost always related to power supply.
Source: RPED Case Study Data, 1993.

When asked to report their chief problem, three-quarters of the firms mentioned frequent equipment breakdown, while about one-third reported that bottlenecks in the production process were the second most frequent problem. Clearly, maintenance and repair are crucial in Zimbabwe's manufacturing sector. Many breakdowns are occurring because the average age of equipment is old due to past foreign exchange restrictions and the limited supply of machinery of local manufacture. However, there was no firm practicing preventive maintenance at the highest possible level. In terms of the ability to do the work, only three firms were found to be totally dependent on outside help for their repair and maintenance work (these were small plants in which the owner or manager did not have technical knowledge), while at the other end, six firms had a complete service in-house. As shown in Table 5.13, half of the firms had the capacity to not only oil and replace accessible parts, but also to strip most machines and to replace standard parts or get spares made to order. In this group, the most frequent maintenance task done outside the plant is the rewiring of electric motors. In a few cases of large plants, outside help is also obtained to insure that the annual overhauls of the main machines and equipment are done properly.

Quality Control. Until the ERP, quality control was not a very important aspect of the production process of most manufacturing firms, as the local market absorbed almost any product. Today, all seem to have some form of quality control, although it is simply a visual inspection in 60 percent of the cases interviewed. The remaining 40 percent of plants used laboratory tests and applied national or international standards. This group is made up mainly of plants in the food sector and those that export.

Table 5.13
Zimbabwe — Firm Distribution by Overall In-house Repair and Maintenance Capability
(Case Study Sample)

Category	*Number*	*Percent*
1. Totally dependent on outside help	3	7.32
2. Self servicing, oiling, replacement of belts or similarly accessible items	9	21.95
3. Same as in 2, plus capacity to strip most machines to replace standard parts or getting spares made	21	51.22
4. Complete repair and maintenance services in-house	6	14.63
5. Other	1	2.44
6. Not available	1	2.44

Note: "Other" includes a firm that has only manual hand tools, but no machines.
Source: RPED Case Study Data, 1993.

Quality control is done by virtually all firms at the final product stage to avoid problems with consumers (see Table 5.14). It is also done by more than 80 percent of plants at the time of purchase of raw materials and components, and during the process of production. The decision of when to do quality control varies depending on the type of process and on market conditions. For instance, in furniture plants, visual quality control is applied to parts in process to make sure that scratches and other imperfections are corrected before the furniture is assembled. In cases where there is limited supply of raw materials or intermediate products, management has to take what is on the market and does not apply any quality control at the time of purchase.

Table 5.14
Zimbabwe — Existence of Quality Control and Its Level

Existence of Quality Control for:	*Number of Firms*	*Percent*
Final Product	40	97.6
Process(es)	35	85.4
Raw Materials and Components Purchases	34	82.9
Materials and Components in Process	25	61.0

Source: RPED Case Study Data, 1993.

More sophisticated quality control procedures are beginning to find their way into Zimbabwe via larger companies and exporters. The Kawasaki Production System (KPS) has been introduced by several exporters. For example, a large furniture exporting firm adopted the system under a license agreement two years ago to try and reduce its costs so as to compete with a Brazilian rival which was cutting into its markets. The technology case study also found the KPS seriously applied by MW491 (see Table A-9 in Appendix A), a major metal working firm, with the dual goals of reduced material handling time and increasing operational profits. Firm TG271 has integrated quality control into its efforts to export; the firm uses standard laboratory tests on fabrics, printing and dyes, and uses technical assistance for quality control from foreign licensers. Firm FP401 follows rigorous quality control procedures as a condition of its license to manufacture an internationally known brand. Its quality control effort includes sophisticated laboratory testing for adherence to biological and aesthetic standards. Significantly, this firm had quality control problems under a previous plant superintendent, which were cleared up under new management.

Rejection rates are a good quality indicator. All plants visited were quite concerned about rejection rates by consumers, and all argued that these were quite low. In many cases, they explained that they had developed systems to reject products before they got to the consumer. The concern about consumer rejections was greater in the food industry and in exporting firms. The recent economic opening was reported to have contributed to a lower rejection rate in some plants because of the increased availability of some inputs. In the clothing sector, many of the rejections were blamed by management on the low quality of cloth available in the local market. The age of the machinery and equipment was also cited as a cause of low-quality products and high rejection rates. For example, an old foundry was found to produce castings that had to be redone in 10 percent of the cases.

It is very difficult to establish a rejection rate trend because most plants do not keep accurate records. However, in the survey, there were questions about rejection rates in 1990 and 1992. On the whole, rejection rates for food, textiles and wood working are quite low, averaging 2 percent or less. Only metal working had a relatively high 6.5 percent average rejection rate. This higher rate in a more complex industry like metal working may signal technical capability difficulties.

Industrial Engineering. As a function, industrial engineering is concerned with the systematic assessment and improvement of plant productivity. Very little organized activity to continuously assess and improve productivity was found in the sample firms. A number of firms did have good manual or computerized systems of inventory control, but these were generally not integrated with the planning of production. The determination of work standards, where they existed, was based on experience and the task was generally assigned to the plant manager or his foremen. The plant layout was generally assessed only when new equipment was brought in or there was new construction.

As noted previously, a couple of firms had partially installed the Kawasaki Production System (KPS) which seems to be a fad in some circles in Zimbabwe. Training in the system is done by a local accounting firm with the appropriate license. The approach integrates production, quality control, and productivity techniques. It requires thorough, continuous follow-up after installation, claiming substantial amounts of managerial time and attention. Hence, it is only really applicable in larger operations.

It should be noted that the University of Zimbabwe does not train industrial engineers. The Scientific and Industrial Research and Development Centre (SIRDC) is planning to have a mechanical and production engineering institute and a department of industrial management.

Safety and Environmental Control. Concern for safety and, in particular, for pollution, are relatively new topics in developing countries. Work-place regulations tend to be quite primitive and worker safety generally does not have a very high priority. Preoccupation with the environment was in the past considered a "rich man's" problem, but it is now generating some attention due to the increased incidence of air and water pollution as a result of uncontrolled industrial production.

Attention to safety was specifically assigned to company personnel in 38 percent of the firms, and for pollution control in 12 percent of them. *Food and beverages* had the highest proportion of plants with safety responsibility assigned to a specific employee (all of them large firms). Written safety rules existed in only one-third of the plants, and for pollution control in one plant.

Product Technologies

Product Design. In practice it is often difficult to distinguish product from process changes. The ability to produce according to own design is an important measure of a firm's technological capabilities. The textile and garment sector, especially in developing countries, responds to products designed by specialized firms operating close to or making the market. The ability to respond to rapid changes in product design is important for the success of these firms. In Zimbabwe, the textile and garment sector appears to be focused largely on the domestic market. In 44 percent of the cases, design was generated by the factory following local buyer specifications; in 30 percent of the cases, the design was a knock-off of an imported product; in 14 percent of the cases, the factory was executing foreign-specified design; in 3 percent of the cases, the product was a knock-off of a domestic design; in 9 percent of the cases, the source of design was not specified. Technology case study firm FP361 has an active product design department under a Technical Director. This department designs products and makes substantial technical changes on other products, and then documents and disseminates the information through a technical manual. The contribution of the department's new products amounted to 1-2 percent of sales over the period 1988-1991.

Although fundamental design was not a widespread skill, 80 percent of the firms surveyed introduced some changes to a product's design. Most of these changes were relatively minor and intended to adapt a product to changes in market demand, or adapt to local taste or inputs. Half of the survey firms introduced what they deemed "new products" last year. Most of these were developed in-house with no external help. In the metal working and textile sectors, for example, factories made new products to models provided by a buyer. As it is export-oriented, WW231 produces furniture and parts entirely to foreign specifications. While it has modified foreign-specified designs to meet market or equipment needs, these were not significant changes.

Learning Mechanisms

The last two sections assessed the current endowments of enterprise investment and production capabilities. The focus now turns to the dynamic elements of technological development — learning mechanisms.

As noted in the conceptual framework for this study, firms improve their technological capabilities, or "learn," over time through a number of mechanisms internal and external to the enterprise. Internally, firms learn from sources ranging from accumulated production experience to proactive programs to acquire skills and information and develop new products through on-the-job training, the acquisition of technical documentation, research and development and the development of technical offices inside the company to provide information on productivity improvement and quality control. External to the firm, private and collective learning channels exist, each with a number of potential learning mechanisms, which the firm can draw on to improve its technological capabilities.

In private channels, transactions with buyers and suppliers, equity investors and foreign partners all provide an important flow of technical information. Similarly, firms interacting with other business enterprises in the same industry in horizontal and vertical networks obtain valuable technological insights. Training programs and hiring consultants are other external sources by which firms can acquire expertise. In the so-called external collective channels, learning is facilitated by the activities of publicly-funded technology institutions, NGOs, business associations or donor agencies which work with firms on specific technology problems, and by government efforts to increase technology transfer to the country.

Taken together, these learning channels are a key driver of manufacturing growth. If they are weak or missing, the long-run supply response to policy reform programs can be slowed and diminished. This section evaluates the strengths and weaknesses in the internal and external sources of learning in Zimbabwe.

Internal Sources of Learning

On-the-Job Training. In-house training for new shop-floor workers is widespread in Zimbabwe, but varies significantly among sectors and firm size classes. As might be expected, larger firms, and particularly multinational corporations, have the most formalized and rigorous training programs. In the late 1950s, a formal apprenticeship system was also introduced in Zimbabwe, but only for Europeans. It operated in seven fields: printing, hairdressing, construction, automotive, electrical, mechanical and aircraft. At independence, this system was opened up to all Zimbabweans. Between 1,000 and 2,000 apprentices were registered annually by firms in 1960s and 1970s, but today the number has declined substantially to the point where it is difficult to find an apprentice on the job in manufacturing. Most of the apprentices receiving training today are working in parastatals, such as the National Railways of Zimbabwe, which has a training center attached to the Bulawayo Technical College.

Case study interviews found that many enterprise managers preferred to hire workers with little previous training or job experience for shop-floor jobs and run them through a company on-the-job training program. It was often stated that the unskilled labor supply was so abundant that one could choose workers easily with high natural ability that require relatively short on-the-job training. There seemed to be widespread belief that the quality of formal education in the country was low and made workers "inflexible." For reasons not clearly understood, dissatisfaction with the "educational" system was particularly strong among textile and clothing industry managers. Indeed, at one time, their producers' association had financed and operated its own school. Because of the heavy cost burden of training, a few years ago they requested the government to use some of the education tax levy to assist in financing the operation. When the government refused, they had to close the school. Currently, plans are being made to reopen it.

After the initial period of on-the-job training for new workers, there does not appear to be much training going on to continuously upgrade shop-floor personnel. This is confirmed in the RPED survey of firms, which questioned a random sample of workers in each plant. Approximately 1,600 workers, all of whom had been on the job at least a year, responded to two questions: (i) Are you currently receiving any in-house, on-the-job training?; and (ii) Are you currently receiving any training outside the firm? Table 5.15 shows the worker responses for each size class of enterprise. Three conclusions can be drawn from the data: (i) overall, continuous training of shop-floor workers is low; (ii) the frequency of the training which does occur is higher in larger firms; and (iii) external sources of training seem to slightly more important than internal sources and are again used more by larger firms. Across sectors, the table also indicates that in-house, on-the-job training occurs most frequently in food and metal working.

Table 5.15
Zimbabwe — Training for Shop-floor Workers by Firm Size and Sector
(Percent)

	In-house	*External*
Firm Size (No. of Employees)		
<10	1.4	2.4
11-49	6.6	4.6
50-99	4.9	5.9
100-249	10.7	12.5
>250	14.2	22.9
Sector		
Food	9.2	14.7
Textile and Garments	6.8	10.2
Wood working	5.7	7.7
Metal working	13.5	10.9

Note: One thousand six hundred workers were interviewed in firms of all sizes.
Source: RPED Survey Data, 1993.

Training programs for technical and professional personnel were not found to be widespread in Zimbabwe. However, the frequency of such programs varied by firm size and sector. Training was most common in the food sector. More than 60 percent of the case study firms offered training to technical and professional staff. All of these firms were large companies. The sectors which employed the fewest number of professionals — textiles and clothing and wood working — provide the smallest number of training programs. In the middle were the metal working companies, which provided training in a little over 40 percent of the cases. Training programs included courses in new production lines, managerial skills, quality control and computers. Some large firms even offered managers university programs, such as MBAs. Some courses were taught in the firms by contracted suppliers, parent firm personnel and upper-level managers. Others were taught externally; some were even sent to foreign universities.

Organization of Technical Knowledge and Functions: Technical Documentation and Technical Offices. Technical information in the firm has two important uses. First, it helps firms learn about more sophisticated products and production technologies by, for example, facilitating re-engineering. Second, it assists on-the-job learning and diffusion of knowledge within the firm, as well as maintenance of quality control. Technical personnel assigned to particular technical jobs or so-called technical offices create and facilitate the use of technical documentation.

In Zimbabwe, the technical documentation used varied widely among industries and firm size classes, as might be expected. Smaller firms on average are much less likely to use technical written documentation than larger firms. But, in all firms, and in comparison to more advanced countries, a substantial proportion of technical know-how used in production in the case study firms remains uncodified, i.e., has not been spelled out in written instructions. In the food industry, where documentation was relatively widely used in production, 80 percent of the case study firms used written recipes, manuals and other documentation and various "specifications." Several smaller operators said that know-how is tacit and diffused by word of mouth through the managing director. In the textile and clothing industry, 70 percent of the firms used patterns and models, or blueprints and manuals, with the client also providing styles. Again, most small firms had tacit knowledge diffused by word of mouth through supervisory personnel. In the wood and furniture industry, some small operators had no documentation. Larger firms used cutting lists, drawings, sketches, blueprints, instructions, manuals, catalogues and templates. Several smaller firms also used drawings obtained from customers. Finally, in the metal working industry, most firms used instructions, blueprints, product specifications, manuals and technical drawings. A few, very small firms had no documentation.

Foreign technical literature has also been an important source of learning for firms, particularly exporters in textile and garments and furniture. Fashionable product designs from abroad, ideas for new machinery and equipment, and marketing prospects were all cited by respondents as information benefits they continuously received from these publications. Many firms, small and medium operators especially, stated that they had difficulty getting access to foreign technical material on a regular basis.

To understand more about internal sources of learning in Zimbabwean firms, the case study inquired about how firms organized the technical personnel employed. For example, did firms have specific technical offices where staff were dedicated to specialized technical functions, such as product engineering, quality control, laboratory, R&D, experimental plant, and the like? Such a functional division of labor will, of course, only show up in larger firms where workers are more specialized. However, in these larger companies, it is interesting to see if labor is organized to focus on particular learning tasks.

The most frequently found technical office across all sectors and firms was the quality control laboratory. All of the large food companies have a lab dedicated to quality control, and often product design and experimentation. Design offices were found in 70 percent of garments firms and 40 percent of furniture makers. Drafting offices turned up in larger metal working companies, as well as tool and die departments. Dedicated industrial engineering offices and R&D offices were few and far between. Only about 12 percent of companies in the case study sample had a dedicated R&D office, although, as just noted, quality control labs in the food industry often performed R&D tasks. In sum, the evidence seems to indicate that Zimbabwean firms, are not well focused organizationally on learning and upgrading activities. However, this inquiry was not very detailed and probably misses some of the picture, and is sensitive to the number of firms in the case sample. Table 5.16 shows the distribution of the case study firms according to the existence of both documentation and technical offices. The figures indicated that there are very few exemplary firms in Zimbabwe in terms of these two internal learning mechanisms. But, in addition, if one compares the frequency distribution in the table with the firm size distribution of the sample, there is a very close match.

Table 5.16
Zimbabwe — Distribution of Firms by Overall Level of Technological Organization

Level	*Frequency*	*Percent*
No documentation or files, no technical offices	22	53.7
Very little documentation, isolated drawings, charts or sketches, and/or up to two technical offices	13	31.7
Good technical documentation and/or three or more technical offices	6	14.6

Source: RPED Case Study Data, 1993.

Research and Development. As just indicated, Zimbabwean manufacturing firms' organizational structures do not reflect much internal learning activity through R&D. The RPED 200-firm survey and the enterprise case studies confirm this conjecture. Enterprise managers were asked whether or not their firms were involved in any "...systematic activity undertaken to increase the stock of knowledge in the enterprise, including fundamental research, applied research, and experimental development leading to new devices, products or processes."[56] Respondents were also asked to specify how many employees spent time in these activities, their educational backgrounds and the amount of resources devoted to R&D.

The results are set out in Table 5.17. Of the total number of enterprises questioned, only 26 percent stated that they had allocated resources to R&D activities. As Table 5.17 indicates, most R&D efforts in product development or process changes take place in a few large or medium-sized firms. By sector, the number of firms involved in R&D are rather evenly spread out, except that wood working shows a slight edge. However, by expenditure, the metal working sector seems to have the most active R&D programs, spending 1.85 percent of sales in 1992. In metal working, the case studies found firms capable of designing simply machinery and equipment for agricultural production, pollution control, construction and manufacturing spare parts. Product development for local tastes and incomes was largely the focus of R&D in the food sector. In clothing and furniture, as noted earlier, exporters are introducing modifications to designs to meet foreign specifications. Notwithstanding these technical efforts, in aggregate, the expenditure data support the notion of a very small amount of formal R&D activity; a total of US$2.4 million was spent by the 200 survey firms in 1992 on R&D. In terms of the total personnel allocated to the task in 1992, managers reported a scant 5 scientists, 54 engineers and 167 technicians had been assigned to R&D activities.

[56] Respondents were prompted not to consider as R&D any routine maintenance or quality control activities, even if scientists or engineers were employed in carrying it out.

Table 5.17
Zimbabwe — R&D Activity by Size, Sector and Expenditures

Firms Doing R&D in each Size Class		*Firms Doing R&D in each Sector*		*R&D as a Percent*
No. of Employees	*Percent*	*Sector*	*Percent*	*of Sales (by Sector)*
<10	5.6	Food	26.5	.11
11-99	21.5	Textile	22.6	.16
100-249	28.3	Wood	37.5	.42
>250	45.8	Metal	26.3	1.85

Source: RPED Survey Data, 1993.

To a large extent, firm-specific abilities to learn, as well as endowments of technological capability at any point in time, depend significantly on the availability of technical personnel. The fact that Zimbabwean firms did not engage in much formal R&D in 1992 reflects the fact that the skills needed to do such work are quite sparse in manufacturing.[57] Lack of key technical personnel may also preclude other, less formal kinds of R&D activities, which is important for enterprise efficiency. Table 5.18 shows the total number of scientists, engineers and technicians employed in the 200 firm sample of manufacturing firms. Clearly, the overall proportion of technical personnel is quite small. Scientists (most likely chemists) are only evident in the food and beverage sector, where chemical lab tests are required for quality control. Engineers seem to be concentrated in metal working, and technicians in textiles. In terms of the concentration of these key technical personnel by firm size, Table 5.19 indicates that the three largest firms in the sample employ the lion's share of scientists and roughly half of the engineers and technicians.

Table 5.18
Zimbabwe — Employment of Scientists, Engineers and Technicians by Sector

	Total	*Scientists*		*Engineers*		*Technicians*	
Sector	*Employment*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Food	15,983	103	0.64	22	0.14	280	1.75
Textiles	2,496	1	0.00	38	0.12	58	2.32
Wood	32,411	0	0.00	3	0.12	353	1.09
Metal	5,479	1	0.02	31	0.57	115	2.10
Total	56,369	105	0.19	94	0.17	806	1.43

Source: RPED Survey Data, 1993.

[57] It has been argued (Pack 1993) that domestic resource costs of various economic activities are quite sensitive to such scarce resources. It may be that, for the lack of a few textile engineers, for example, a country is excluded from having a viable textile industry.

Table 5.19
Zimbabwe — Concentration in Employment of Scientists, Engineers and Technicians

Personnel	*Total No.*	*No. of Employing Firms*	*No. Employed by Three Largest Employers*	*% of Total Number*
Scientists	105	8	91	86.67
Engineers	94	21	50	48.08
Technicians	806	52	373	46.28

Source: RPED Case Study Data, 1993.

External Sources of Learning

In addition to technical efforts made inside the firm to upgrade capabilities, Zimbabwean entrepreneurs are tapping external learning sources, such as knowledgeable buyers and suppliers, expatriate personnel and technology support institutions. An assessment follows of the purely private channels for external learning.

Transactions with Buyers and Suppliers. While the RPED survey and case studies were unable to provide specific statistical evidence of the transfer of technology through these mechanisms, there is a good deal of qualitative evidence that business transactions with buyers and suppliers, foreign and domestic, are one of the most important sources of learning for Zimbabwean firms. Suppliers of equipment and other inputs transfer a good deal of knowledge when assisting with the technical aspects of purchasing, installing, commissioning and periodic equipment overhaul. About 40 percent of firms in the survey specifically stated that suppliers run training courses (domestically and abroad), provided technical documentation (which assisted in training) and helped with troubleshooting and production planning. Entrepreneurs in the case studies also stated that suppliers also provided information on best practice methods in the industry, which were helpful in seeking productivity improvements. Buyers have also been a tremendous source of information and learning, especially in the case of exporters. Case studies found that buyers' samples and design specifications have been a major source for product development in furniture and garment companies. Foreign buyers are also assisting Zimbabwean exporters to become more cost competitive and to reduce production turnaround times. One large German buyer in the garments industry, for example, has a permanent expatriate staff member living in Zimbabwe for the sole purpose of working with local producers to upgrade quality and enhance production efficiency. In the furniture industry, the case studies revealed several cases where foreign buyers are assisting exporters to introduce new designs and/or to produce existing products more competitively.

Interaction with Other Firms. The potentially rich information environment which can be created by vertical and horizontal links between firms is weak in Zimbabwe. Part of the reason for this is that manufacturing activity is still relatively low in the country. But, two other important contributing factors may be the extent of imperfect competition in manufacturing, and the socioeconomic divisions that exist in society. First, as noted in the background section to this study, manufacturing in Zimbabwe tends to be highly concentrated. Vertical and horizontal linkages among subsidiaries of large, oligopolistic firms exist, but there is little competition within market segments and thus limited opportunity to gain from "learning spillovers" which occur by way of benchmarking one firm's operations against those of a similar competitor's.

Second, informal linkages among local entrepreneurs in Zimbabwe are relatively strong. Zimbabwe's business world is a small one in which everyone knows everybody else's business. White and elite black leaders in business interact in business transactions and frequent the golf and social clubs today. But there are very few large black firms and thus parallel information networks exist, often non-intersecting, among whites and blacks. This, and the fact of Zimbabwe's historical organization along color and ethnic lines, explains in part the local reluctance to enter into formal business interactions, such as subcontracting. The relatively low levels of technical and engineering skill levels in the black community also reduce the possibility of subcontracting. Lack of such formal business transactions severely reduces the possibilities of technological learning.

Employment of Expatriate Staff. Another way to learn is to import expatriate staff with knowledge of superior technology. The RPED survey indicates that only about 10 percent (20 firms) of firms in the sample employed expatriate staff. In total, these enterprises (all large or very large) employed only 42 expatriates in two capacities, as managers and as engineers or technicians.[58] These data seem to reflect the isolationist history of the country and the strong self-sufficiency that developed among local entrepreneurs.

Technical Assistance Contracts and Licenses. Technical assistance contracts and foreign technology licenses are other external sources that Zimbabwean firms use to access technology and information markets. Firms that contract foreign technical assistance or operate under foreign technology licenses are engaged in a form of technical effort. However, the survey and case study data indicate that few Zimbabwean manufacturers use these mechanisms to access foreign technology. The survey of 200 firms shows that only 15 percent (29 firms) hold foreign licenses. Most of these firms (20 firms) have more than 250 employees. Many of these plants are in the food and beverage sector (13 firms), where one would expect the presence of international brands, and where scientific knowledge is necessary to achieve and maintain high levels of quality. Some enterprises have licenses in textiles and garments (11 firms) and a few in metal working (5 firms). About 70 percent of the firms that hold foreign licenses also have some percentage of foreign equity participation. 11 of the 29 firms which hold foreign licenses are more than 50 percent foreign-owned. The average amount spent by a firm on these foreign licenses is approximately US$50,000 annually.

[58] The survey may underestimate the number of expatriates employed because "expatriate" is sometimes interpreted as excluding Zimbabwean residents who are not Zimbabwean citizens.

Only 27 firms (13 percent) reported having a foreign technical assistance contract. Again, most of these contracts are concentrated in very large firms, many with foreign ownership shares, in the food and textile and garments sectors. Firms with greater than 250 employees accounted for 60 percent of the reported technical assistance contracts. The food sector accounted for 40 percent of the technical assistance, and textiles and garments for more than 30 percent. The mean value of expenditures per contract in 1992 was about US$25,000. This reported figure is probably an understatement because in some cases the cost of foreign technical assistance is included in the price of inputs purchased from foreign firms. For example, Coca-Cola bottlers pay their foreign technical assistance fees indirectly through a surcharge on the syrup they buy from Coca-Cola International.

External Support Services — Private and Collective. Many of the firms in the survey and case studies reported using some sort of external support services. Most of these technology support services were procured through private channels (more on this aspect later). In the detailed technology case studies of 41 enterprises, managers were asked to provide information on the frequency and type of support services generally used. Table 5.20 provides data on these responses. Interestingly, the use of external support services seems to reflect difficulties caused by the vintage of machinery and equipment currently in service in Zimbabwe's manufacturing sector. The most frequent support service procured from outside the firm is repair and maintenance. Of those questioned in the case studies, 80 percent had used some external support service for this purpose in 1992. Only in the very small enterprises in the sample were these services not used, either because these firms could not afford the service or because they had a limited amount of equipment and did not require the service. Some firms in manufacturing did not use such services very often because the nature of their own production allows them to do most repairs in-house.

Table 5.20
Zimbabwe — Most Frequently Used Support Services

Support Service	*Frequency*	*Percent*
Repair and Maintenance	33	80.5
Technical Assistance	18	43.9
Quality Control, including testing and certification	17	41.5
Employee training	15	36.6
Instruments Calibration	6	14.6
Other	4	9.8

Source: RPED Case Study Data, 1993.

Periodic technical assistance was the second most frequently used support service. In 44 percent of the firms, technical assistance was obtained for a host of reasons, including equipment installation, development of new quality control systems, personnel training, design of new products, and so on. Some of this assistance was provided at no cost by shareholders and parent companies, and four firms received help from international donor agencies. In contrast to maintenance and repair services, there were very few local suppliers of technical assistance services. Proportionally, plants in metal working have sought technical assistance more frequently than in other sectors.

Quality control support was used in about 41 percent of the plants. Not surprisingly, these plants were clustered in the food sector, where sanitary considerations require high quality standards, and in metal working, where products are more complex and require more stringent tolerances.

Training support services were obtained by about one-third of the companies. Most of these firms were also in the food and metal working sectors. These services were used mainly to train middle management and technical personnel. As noted earlier, shop-floor workers are normally trained on the job. Most of the suppliers of these services were local, and training took place locally. In a few instances, suppliers were foreign transnational corporations and equipment suppliers. Even then, training took place locally in most cases.

Instrument calibration was the next most frequently used support service. Again, most of the users were in the food and metal working sectors. These services were provided by local suppliers, such as the Standards Association of Zimbabwe and the University of Zimbabwe (these collective support services will be discussed later).

During the survey, entrepreneurs were provided a support service wish list from which to choose and rank desired services. The managers' answers are quite interesting (see Table 5.21). The first was the desire to have additional support services. The most frequently mentioned desired services are those to improve productivity, train personnel, improve production processes and design products. Assistance with labor relations, pollution control, tools, dies and fixture manufacturing, safety systems, pilot plant experimentation and instrument calibration were not considered too important. They were mentioned by less than 20 percent of the managers and ranked low in their priorities.

The focus on the need to increase productivity, change the production process and improve product quality are all new goals for manufacturing plants in the country, and reflect their perceived need to adapt to a changing economic environment. These adaptations require significant changes in their capital equipment and production processes, and in the quality of the labor force.

Support service desires vary across sectors. Assistance with productivity techniques was important in all sectors, but it was of overwhelming importance in food and beverage, where 11 of 13 firms mentioned it and ranked it very high. Training was more important for textiles and clothing (6 of 10 firms). Product design assistance was not desired much in food and beverages, but it was important in other sectors, especially in furniture and metal manufacturing. Technical support to improve safety, pollution control, energy saving and instrument calibration was not desired by any of the textile firms. The need for assistance in pollution control (4 of 7 firms) was expressed by food and beverage plants, and most tool, die and fixture manufacturing assistance needs (3 of 7 firms) were in metal manufacturing. These results are expected as pollution problems can have greater impact on food product quality, and tools, dies and fixtures are more needed in metal manufacturing.

Table 5.21
Zimbabwe — Highly Desired Support Services

	No. of Firms Interested	*No. of Firms Ranking It*	*Weighted Rank*
Productivity Techniques	28	25	2.97
Employee Training	24	22	2.51
Quality Control Testing	14	14	1.55
Process Improvement	19	14	1.51
Product Design	18	13	1.23
Repair and Maintenance	13	11	1.12
Troubleshooting Assistance	13	11	1.1
Energy Saving	12	8	0.83
Labor Relations	8	4	0.64
Pollution Control	7	5	0.46
Tools, Dies or Fixtures	7	4	0.43
Safety	5	4	0.33
Pilot Plant Experimentation	4	1	0.06
Instruments Calibration	2	0	0

Source: RPED Case Study Data, 1993.

The availability and use of collective delivery mechanisms for business support services in Zimbabwe is low. The enterprise survey of 200 firms asked about the use of seven of the most important technology support services run by government or industry associations in Zimbabwe. Table 5.22 shows the number of enterprises using these services in 1992, together with information on the frequency of each firm's use during the year. Overall, Table 5.22 indicates that the use of collective technology services is low. Only about one-third of the firms in the sample utilized any of the available services. The Standards Association of Zimbabwe is used by the largest number of firms and, on average, is visited 12 times during the year by each user. This is followed by the Department of Research and Specialized Science at the University of Zimbabwe. The metal working and food sectors have the highest recorded demand for these support services (Table 5.23), and it is the largest firms which use them most frequently.

Table 5.22
Zimbabwe — Usage and Frequency of Use of Collective Technology Support Mechanisms

Institution	*No. of Firms Using in 1992 (Percent)*	*Frequency of Use in 1992 (Avg. No. of Times)*
Standards Association of Zimbabwe	16	12
University of Zimbabwe	3	7
Scientific and Industrial R&D Center	2	4
Clothing Institute	0.5	1
Timber Advisory Board	0.5	2
Zimtrade	0.5	1
Association of Packing	0.5	3
Other	0.5	6

Source: RPED Survey Data, 1993.

Table 5.23
Zimbabwe — Number of Firms Using Key Support Services by Sector, 1992

	Standards Assoc. of Zimbabwe	*Scientific & Industrial R&D Centre*	*Clothing Institute*	*Timber Advisory Board*	*Zimtrade*	*Assoc. of Packaging*	*Other*
Food	14	0	0	0	0	0	1
Textiles	4	0	3	0	3	1	3
Wood	3	0	0	2	0	0	0
Metal	10	4	0	0	0	3	4
Total	31	4	3	2	3	4	8

Note: 'Other' includes David Whitehead Laboratories, Overseas Institute, Dunlop, Engine Reconditioning Association, Motor Trading Association, and Leather Institute.
Source: RPED Survey Data, 1993. Sample of 200 firms.

6. Technological Capabilities and Learning Mechanisms: Kenya

Background to Technological Development

Historical Setting and Recent Economic Performance

On the eve of independence from Britain, industrial activity in Kenya was more intensely developed than in any other part of tropical Africa except (then) Southern Rhodesia (McWilliams 1976).[59] Nevertheless, the industrial sector in Kenya was quite rudimentary, consisting of processing of agricultural products and the manufacturing of a few consumer goods. The most important group of manufacturing activities revolved around the provision of food, drink and tobacco products. Some of the food processing activities (meat processing, dairy produce, grain milling) had developed after World War II through the creation of statutory organizations and the financial help of the colonial government, while others (canning, confectionary, drinks, tobacco) were spurred by private capital, both international and local (McWilliams 1976). The structure of manufacturing activity was geared primarily towards meeting the needs of the domestic market with limited exports to other East African countries and, to a smaller extent, to overseas markets.

In the three decades since independence in 1963, the first half was a period of stability and sound growth while the second one has been characterized by severe problems and macroeconomic imbalances. Kenya's industrial policies immediately after independence were characterized by an emphasis on self-sufficiency through import substitution and an active role for state, although the government also pursued a fairly open policy towards foreign investment. For the first decade after independence, the country had a strong growth rate of GDP (over 6 percent per annum), low inflation, fiscal balance and stable exchange rates. There was considerable foreign investment in the import-substituting industries, often with state participation, during this period and manufacturing grew by almost 10 percent per annum. The adverse impact of the oil shock in 1973 was mitigated in Kenya by a dramatic increase in world coffee prices in 1975. Since Kenyan manufacturing is significantly dependent on imported inputs, the availability of foreign exchange led to continued strong manufacturing growth rates until the beginning of 1980s (see Table 6.1). However, the macroeconomic situation of the economy, both in terms of internal and external balance, was deteriorating concomitantly with the sound GDP growth rates. The second oil shock of 1979, a reversal of coffee prices to normal levels by 1980, and an inability to reverse the growth in government expenditures during the coffee boom, all contributed to the overall budget deficit of Kenya reaching a peak in 1980. High fiscal deficits and macro imbalances were fueled by money creation and external financing; the latter, between 1978-81, accounted for 15 percent of government expenditure. The severe and deteriorating macroeconomic situation elicited pressure from the World Bank and the International Monetary Fund (IMF) for devaluation and other measures aimed at

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[59] This chapter is based upon the results of field work conducted in Kenya in 1993, and an internal report prepared for RPED as "Technology and Skills in Kenya Manufacturing" in 1994, by RPED consultants Simon Teitel and Ricardo Soifer, as well as their collaborators, Gerrishion Ikiara and Wafula S. Masai of the University of Nairobi.

liberalization and structural adjustment. The resulting reform measures, however, were sporadic and implementation was less than consistent until the mid-1980s following the severe drought in 1984.

To cope with the drought, the worst since the 1930s, Kenya signed a new stand-by agreement with the IMF in February 1985, on the condition that government expenditures would be restrained, trade liberalization strengthened and the exchange rate kept close to its competitive levels. The government budget deficit came down to 4.1 percent of GDP in 1987-88, from 6.6 percent the year earlier. However, slow export growth, adverse terms of trade movements and the relatively rapid growth of imports kept Kenya's external position deteriorating during most of the early 1990s. During 1991-92, per capita incomes actually fell, accompanied by a severe downturn in Kenya's relationship with its external donors. More recently, however, the Kenyan government continued to articulate its commitment to pursue these reforms intended to increase competitiveness of the manufacturing sector. Between February and May 1993, the exchange rate was gradually devalued by 75 percent while money supply growth was severely curbed and many prices in the economy decontrolled.

Table 6.1
Kenya — Selected Aggregate Statistics

	1964-72	*1973-80*	*1981-85*	*1990*
Real Growth (%)				
GDP	6.6	5.1	3.7	4.5
GDP per capita	5.2	0.8	0.2	1.1
Industry	11.1	7.5	1.3	5.2
Manufacturing	9.6	10.6	3.8	5.2
Private Investment (% of GDP)	11.5	12.1	13.4	10.0
Exports (% of GDP)	33.5	29.7	26.2	25.5
Industry (% of GDP)	12.9	15.7	16.1	16.8
Manufacturing (% of GDP)	7.8	11.0	12.1	13.2

Source: Regional Program on Enterprise Development (1993b). "Economic Development and the Manufacturing Sector in Kenya," Table 2.1, Country Background Paper. Prepared for the World Bank by the Department of Economics, University of Nairobi, Kenya, and Department of Economics, University of Gothenburg, Sweden, July 1993.

Manufacturing Sector in Kenya: Background

The bulk of Kenya's manufacturing industry is located in the southern parts of the country, along a belt that stretches from Kisumu in the west to Mombasa on the coast. The largest industries are situated in Nairobi, Mombasa, Nakuru, Eldoret and Kisumu.

As already noted, the manufacturing sector expanded in the immediate post-independence years in part due to increased foreign investment, usually by multinational companies. In many cases, the foreign investors were joined by the state as equity partner leading to numerous joint ventures. At a smaller scale of activities, industry and commerce in Kenya are distributed along distinct ethnic patterns with an important role played by Kenyans of Asian ancestry (mostly Indian and Pakistani). Brought to Kenya as laborers during the colonial period and prohibited from owning land, the Kenyan-Asians found economic opportunity in trade and commerce. After independence, and partly due to restrictions on their entry into retail and wholesale trade, the Kenyan-Asians moved into manufacturing also. They now dominate as much as 90 percent of the trading sector while their share in the industrial sector is close to 55 percent (Ungar 1989, pp. 167). Structurally, therefore, in terms of ownership structure and scale of activities, the industrial sector in Kenya appears to be three tiered: the largest firms in the economy are characterized by public sector ownership or ownership of multinational companies while the numerous microenterprises and small firms, including those in the informal sector, are predominantly owned by Kenyan-Africans; Kenyan-Asians are the most frequent owners of firms in the middle of this size spectrum.

Overall, the evolution of the manufacturing sector since independence shows a mixed picture of growth and structural deficiencies. Thus, the industrialization and impressive growth rates in the 1960s and 1970s have not led to a proportional increase in the share of manufacturing in the aggregate economy. Industry employed 26 percent of the formal labor force in Kenya and contributed about 13 percent of the GDP in 1991 compared to 11 percent in 1970.[60] In addition, within the manufacturing sector, there has not been any significant shift from the "traditional," resource- and labor-intensive industries such as food processing, textiles, and furniture, into the more modern industries — such as machinery, chemicals, metal products, etc. — that are characterized by greater capital and skill intensity. On one hand, whole new industries have developed (e.g., plastics processing, pharmaceuticals, steel rolling and galvanizing, etc.) while others have deepened from a few small establishments into industries with many firms producing a wide range of products. At the same time, there are large gaps in the industrial base. The chemicals industry (pesticides, fertilizers, industrial acids, textile dyes, etc.) is sorely underdeveloped; existing foundries and workshops are mostly unable to do high-precision work; and, most agricultural equipment and hand tools are imported, as are most components of locally assembled consumer goods and durables. The food processing sub-sector, dominant at the time of independence, is still the most important, accounting for almost 46 percent of the manufacturing output in 1990.

The food processing and metal working sub-sectors, as will be seen in later chapters, have on average greater technological capabilities than the other two sub-sectors studied here. A partial reason may be that the food processing sub-sector received an increased proportion of foreign investment in the 1980s, which in the previous decade had gone mostly into the textiles sector. Although the metal working sector has traditionally benefited from strong backward linkages from the railways, its share in manufacturing value-added has *decreased* from 16 percent to 10 percent since 1970. However, the metal working sector is sufficiently technologically developed to manufacture, for instance, contemporary technology demanded by

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[60] This compares with a share of manufacturing in GDP equal to 10 percent in Ghana and 26 percent in Zimbabwe.

the country's rapidly growing fast food market.[61] Both the other sub-sectors included in this study have declined in their share of manufacturing valued added since 1980: clothing and textiles (and leather) constituted 3.3 percent of manufacturing output in 1990 compared to 8.6 percent in 1980 while the corresponding figures for wood and furniture are 2.3 percent and 2.9 percent respectively. Data on absolute amounts of production in the four sub-sectors of the study are summarized in Table 6.2.

Table 6.2
Kenya — Quantity Index of Manufacturing Production
(1976 = 100)

Sector	*1980*	*1990*	*1991*	*1992*
Food Manufacturing	110.7	173.2	174.8	164.8
Beverages and Tobacco	135.1	210.7	203.9	230.7
Textiles	175	227.8	218.5	218.5
Clothing	218.3	347.2	323.9	320.9
Wood and Cork Products	135	70.2	73.1	74
Furniture and Fixtures	54.2	73.7	70.8	71
Metallic Products	129.4	177	205.5	186

Source: Regional Program on Enterprise Development (1993b). "Economic Development and the Manufacturing Sector in Kenya," Table 2.1, Country Background Paper. Prepared for the World Bank by the Department of Economics, University of Nairobi, Kenya, and Department of Economics, University of Gothenburg, Sweden, July 1993.

An indirect indicator of technological capabilities in the manufacturing sector is provided by the extent to which the sector can compete with international producers, i.e., export manufactured items. Kenyan export performance has not been very impressive, but between 1970 and 1991, Kenya's exports of machinery and transport equipment increased from 0 to 5 percent, textile and clothing from 1 to 2 percent, and "other manufactures" from 12 to 15 percent of the total merchandise exports. Other African countries continue to be an important market for Kenyan exports, accounting for 30 percent of all exports by value in 1990, behind only Western Europe's share of 39 percent.

Finally, before proceeding to a discussion of the survey data on technological capabilities of Kenyan manufacturing, it would be useful to evaluate the factors of production, namely, the stock of capital and the pool of labor available to the firms, and the development of science and technology in the economy.

Labor

Kenya's total formal employment is approximately 1.37 million or roughly 15 percent of a total labor force of 9.2 million. There exists therefore a very large pool of unemployed and

[61] However, a significant amount of fast food equipment is not manufactured but assembled locally, such as food warmers, grills and refrigerated coolers. Crucial components of such equipment, including gas compressors, gauges and electrical elements are imported.

unskilled labor in the economy. The majority of the formally employed workers are found in the tertiary sector (55 percent) while industry employs 26 percent, the remaining being in formal agriculture (1989 census figures).

Unemployed and unskilled does not necessarily mean illiterate. As seen in Table A-1 in Appendix A, Kenya's educational system appears effective in that primary and secondary enrollments have risen markedly over the last 20 years. The country's literacy rate, defined as the share of population age 15 and above who can read and write, was 69 percent in 1990. By gender, 80 percent of the male population and 58 percent of the female population is considered literate.

Where Kenya is less successful is in the development of technically trained adults. The technical and vocational training sector in Kenya is comprised of five levels: two years of training for artisans, three years for craftsmen, three years for technicians, two years for technologists and two years for masters of technology. In principle, each level includes six to nine months of compulsory industrial apprenticeship. Eight types of private and publicly funded institutions are involved in the technical and vocational training. Training at the artisan level is provided by Youth Polytechnics, National Youth Services and the Christian Industrial Training Centers while craft-level training is provided by Industrial Training Centers, Institutes of Technology and the Technical Training Institutes. Together, these institutes enroll about 30,000 people per year for artisan and craft level training. Training for technicians is provided at the National Polytechnics while the state universities train technologists and masters of technology.

The shortage of technically trained individuals appears to be a significant constraint in the manufacturing sector. The surveys reported in this study reveal that Kenyan manufacturers do not have the requisite numbers of engineers and certified or diplomaed technical personnel desired to improve their technical capabilities. Firms in the case study survey repeatedly reported insufficient skilled labor as a problem; others reported a desire to use less labor-intensive, automated processes to overcome operator error and absenteeism. Aggregate enrollment ratios reported in Table A-3 in Appendix A are consistent with the manifestation of a skilled-labor constraint in the surveys. Kenya's enrollment of pupils in vocational education programs lags behind the rate for Africa as a whole which in turn lags behind other developing countries.

Capital

A description of the base condition of the country's capital stock can provide a useful context for the discussion of technological capabilities in the manufacturing sector. In particular, the age of the capital stock is likely to be correlated with the modernity of the technology although, in principle, new pieces can also embody old technology. Newer equipment is less likely to break down and interrupt production. Since there are no aggregate data on capital stock in the economy, data regarding age of machinery and equipment from one of the two surveys reported in the study have been used. Kenya's capital goods industry is severely limited. Consequently, a preponderance of the equipment used by firms in the survey was of foreign origin. The most important sources of origin of machinery used by these firms are Czechoslovakia, Japan, UK, Italy, Germany and India. The presence of a foreign equity partner, the parent companies in case of multinational subsidiaries, and sometimes the amount of tied-aid given to Kenya can affect the source of equipment.

An overwhelming 91 percent of the respondents in the survey bought their principal equipment and machinery new, eschewing purchase of second-hand goods. The survey inquired about the age characteristics of the three main machines or pieces of equipment in each plant visited and yielded valid data on 412 items. About 6 percent of these items were less than 5 years old, 16 percent were between 5-10 years old, 27 percent between 10-15 years, and 34 percent between 15-20 years. Thus, almost a fifth of the equipment surveyed is less that a decade old and more than half of it is less than 18 years old. The wood working sector has the oldest machines on average while those in the textiles sector are the youngest. For the sample as a whole, the mean age of machines in this sample is 18.8 years. Combined with the fact that the data are skewed by the presence of a large purchase of machinery by a parastatal (that has now ceased operations), these figures suggest that, although mostly bought new, a substantial proportion of the capital stock in Kenyan manufacturing may be aged and ready for replacement.

Science and Technology

The level of scientific and technological development in the economy provides a critical element of the infrastructure supporting industrial manufacturing. The aggregate scientific and technological infrastructure in Kenya is assessed here by focusing on broad indicators of R&D activities.

On the input side, we consider the stock of scientists and engineers in the country and the aggregate expenditure on R&D. Not surprisingly, both indices lag behind world averages. In 1990, Sub-Saharan Africa had 0.7 percent of the world's total scientists and engineers engaged in R&D; in comparison, the corresponding figure for Latin America and Caribbean is 3.1 percent. Similarly, the total number of scientists and engineers in Sub-Saharan Africa was 469,000, which is one-tenth of that in Latin America and the Caribbean (4.7 million) (UNESCO 1993, Table 5-1).

Even within the context of these low magnitudes for Sub-Saharan Africa, Kenya's share appears less than proportional to its economic weight in the region. Thus, in 1982, Kenya had about 17,000 scientists and 18,000 technicians, together constituting 3.4 percent of the stock of scientists and engineers in Sub-Saharan Africa. This proportion is lower than the country's GDP and population shares in the region which were approximately 4.3 percent and 5.1 percent respectively in 1991, (World Bank 1993b). Further, in per capita terms also, as shown in Table A-8 in Appendix A, Kenya's stock of highly skilled manpower lags behind that of other, relatively poor countries in Asia and Latin America.

Data on aggregate R&D expenditures in Kenya are not readily available. However, a recent report of the National Council of Science and Technology (National Council for Science and Technology 1990) suggests that the government supports R&D expenditure to approximately 0.5 percent of the GDP. The same source indicates that this proportion was higher at the beginning of 1970s but has declined over time. The current figure of R&D expenditure is similar to that found in a number of industrializing countries and higher than the average level for countries in Sub-Saharan Africa (UNESCO 1993, Table 5-2.). For private sector R&D expenditures, data from the firms sampled in the RPED survey can be used. Of the 218 firms responding, only 14 invested in R&D with the total amount being less than US $200,000. The food and beverage sub-sector accounted for 42 percent of this total.

Two internationally comparable output indicators of the results of R&D activities are patents granted and research publications. Table A-2 in Appendix A shows the number of patents granted to residents and non-residents in Kenya and other African countries for the longest period with available information. Quite clearly, the output of industrial research in terms of patents granted is quite low in Kenya as in most Sub-Saharan African countries.[62] Furthermore, the vast majority of patents in Kenya have been granted to non-residents which does not represent industrial research activity carried out within the country. Even the patents granted to residents could belong to the subsidiaries of multinational companies.[63]

Kenya fares relatively well among the Sub-Saharan African countries in terms of production of scientific literature as seen in Table A-5 in Appendix A. The total output of the Sub-Saharan African countries of published scientific papers amounts to 0.5 percent of world output. However, within the region, Kenya's output is second only to that of Nigeria. Between 1981 and 1986, Kenya accounted for 15 percent of the total output of Sub-Saharan African countries with Nigeria's share being 47 percent. However, the distribution of published papers across different subjects shows that the majority of publications are in biomedical and life sciences (93 percent) with only a small proportion of the papers devoted to chemistry, physics, and engineering and technology.

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[62] For comparison, note that a total of 98 patents were granted to non-residents in Kenya in 1985 (and none to residents), while 10 Latin American countries had each more than 100 patents in 1980, with 3 of them having more than 1,000.

[63] For example, according to the NCST report (NCST 1990), 1,025 patents were granted in the country during the period 1970-78, of which only five could be attributed to Kenyan nationals and of which three were found to belong to subsidiaries of multinationals.

Characteristics of the Survey Data

The data on Kenyan firms used in this study are from two sources. The first consists of a primary survey conducted in February-March 1993 by an RPED research team in which a comprehensive questionnaire was applied to 224 Kenyan manufacturing firms.[64] This was supplemented by a case study survey focusing exclusively on technological issues and administered to a sample of 35 firms chosen from the initial sample of 224 firms from the RPED survey. Interviews in the case study were conducted at two levels: general management, usually represented by the owner or general manager of the firm, and, where appropriate, plant management, typically represented by plant manager or plant engineer. Plant visits were an integral part of the interview process in the case study.

Tables 6.3-6.7 provide summary characteristics of the RPED and the case study samples in terms of sector of activity, geographical location, employment size, ownership structure and ethnic background of the owners. In addition, data is also presented on the export behavior of the firms in the two samples.

Table 6.3
Kenya — Industry Composition
(Comparison of Case Study and Survey Samples)

	Food		*Textile*		*Wood*		*Metal*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	9	25.7	6	17.1	8	22.8	12	34.3	35	100
Survey	52	23.3	57	25.6	60	26.9	54	24.2	223	100

Source: RPED Survey and Case Study Data, 1993.

Table 6.4
Kenya — Location Distribution of Firms in Both Samples

	Nairobi		*Mombasa*		*Other**		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	25	71.4	10	28.6	0	0	35	100
Survey	144	64.6	39	17.5	40	17.9	223	100

Note: Includes 21 firms in Nakuru (9.4%), and 19 firms in Eldoret (8.5%).
Source: RPED Survey and Case Study Data, 1993.

[64] Registered firms in the RPED survey sample were selected randomly from the Central Bureau of Statistics' register of firms based on a stratification by three employment levels: 1-6, 7-79, and 80 and above. The sample frame for unregistered firms was based upon a primary (partial) listing of firms undertaken for all four cities. A sub-sample of 40 firms was chosen for the case study of which five firms had to be dropped for various reasons. The choice of the case study sample was not random but aimed at including firms that might enable detailed consideration to technological issues representative of the manufacturing sector.

Table 6.5
Kenya —Comparison of the Size Composition of Both Samples

Sample	*Small*		*Medium*		*Large*		*Total*	
	No.	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	9	25.8	12	34.3	14	40	35	100
Survey	88	39.6	52	23.5	82	36.9	222	100

Note: Small = Firms employing up to 10 workers.
Medium = Firms employing from 11 to 49 workers.
Large = Firms employing more than 50 workers.
Source: RPED Survey and Case Study Data, 1993.

Table 6.6
Kenya — Ethnic Background of Firm Owners

	Asian		*African*[a]		*European*[b]		*Mid East*		*Other*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*N*	*%*
Case Study	20	57.1	9	25.7	6	17.1	0	0	0	0	35	100
Survey	104	51.7	91	45.3	2	1.0	3	1.5	1	0.5	201	100

[a]Includes state-owned firms.
[b]Also includes US firms .
Source: RPED Survey and Case Study Data, 1993.

Table 6.7
Kenya — Ownership Structure, Comparison of Both Samples

	Private (K)		*Private (F)*		*Private (Mixed)*		*Joint Kenyan*		*Joint Mixed*		*State*		*Total*	
Sample	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No..	%
Case Study	28	80	2	5.7	3	8.6	0	0	0	0	2	5.7	35	100
Survey	182	82.4	12	5.4	21	9.5	1	0.5	2	0.9	3	1.4	221	100

Source: RPED Survey and Case Study Data, 1993.

While the RPED sample is about evenly balanced among the four sectors, the case study sample has a higher proportion of metal working firms and a lower proportion of firms in the textiles sector. Unlike the panel survey, the case study survey was confined to two locations in Kenya, Nairobi and Mombasa. Further, with respect to firm size, firms in the case study are significantly larger than those in the RPED sample. Given the correlation between firm size and owner ethnicity in Kenya, this also is reflected in the relatively larger proportion of Kenyan-Asian owned firms in the case study survey. Lastly, the distribution of ownership structure among firms in the two samples is quite similar.

The proportion of firms exporting their output are also comparable across both samples as shown in Table 6.8 This is primarily due to the fact that an overwhelming portion of both samples has no exports at all.

Table 6.8
Kenya — Comparison of Exporters in Both Samples

	Exporters		*0.1-10%*		*11-25%*		*26-50%*		*>50%*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	25	71.4	5	14.3	2	5.7	2	5.7	1	2.9	35	100
Survey	170	78	19	8.7	12	5.5	5	2.3	12	5.5	218	100

Source: RPED Survey and Case Study Data, 1993.

Technological Capabilities and Learning Mechanisms: A Summary Evaluation

Investment Capabilities

Over the course of time, most firms are expected to undertake some investments aimed at replacing depreciated machinery, expanding capacity, upgrading their production techniques or diversify into new markets. Firms in the RPED survey also show a significant amount of investment activity with two-thirds of microenterprises, over 80 percent of small firms and virtually all the larger firms reporting a major addition to or change in plant and equipment since 1990. Almost 90 percent of the firms have undertaken such an investment within the last 10 years. The mean value of investments undertaken by firms during 1990-92 ranges from 9 percent to 18 percent of the replacement value of their capital stock. If all firms in the sample are included, the mean investment to replacement value varies from 9 percent to 12 percent depending upon the firm size class. As shown in Table 6.9, the objective of the investment was overwhelmingly either to add to capacity, to improve the production process or to introduce new products. The outcome of the investment reported by the firms was a reduction in their costs of production per unit of output in at least 40 percent of the cases (except for microenterprises). In a significant number of cases, the investment resulted in an increase in costs which may reflect changes in product quality (not shown) since 60 percent of these firms also reported an improvement in product quality as a result of the investment.

The outcome of firms' investment efforts depends critically on their investment capabilities. These capabilities are discussed in this section as reflected by the firms' responses to their initial acquisition of technology: how, at inception, was the investment project (i.e., the firm) evaluated; how was the technology selected and appropriate machinery identified; how was the equipment installed; and, how were technical problems at start-up solved?

Initial Acquisition

Thirteen of the 35 firms in the case study survey started as small operations without any formal feasibility studies being carried out. Another eight firms also did not undertake such studies although they started out on a larger scale with a full production line. Leaving aside seven firms which were acquired as going concerns because there is no information about whether pre-investment studies were initially carried out, only 8 cases remain where firm inception was preceded by formal feasibility studies. The absence of feasibility studies as a norm obviously does not necessarily imply an absence of substitute (entrepreneurial) input aimed at achieving the same objectives as would be sought by a formal study. One should not infer that firm formation is undertaken without evaluating the feasibility and prospects of the venture.[65] Instead, these numbers suggest an absence of a well-developed market catering to the provision of such services at low cost to a wide spectrum of users. Analogous to the self-financing seen by entrepreneurs in the absence of deep financial markets, the entrepreneur interested in investing may have to carry out a feasibility study on his/her own.[66] The absence of a deep market providing information-based services to potential entrepreneurs may also reflect absence of institutionalized availability of data relevant to undertaking such analyses. In any event, the reliance of entrepreneurs on themselves is a frequent aspect of firm decisions related to technological choices.

For example, the decision about which technology or equipment to acquire at start up was made in 46 percent of the cases solely by the entrepreneur on the basis of personal experience. The next most important basis for deciding on choice of equipment was reported by firms as a trip abroad to observe the equipment (nine cases). These trips were organized in some cases by the local agent of a distributor or by international partners of the firm. Not surprisingly, foreign firms or joint ventures usually relied on their headquarters or international partners for obtaining the relevant information. Other firms made their choices based upon information supplied by a licenser or by foreign embassies. Once again, local engineering personnel were seldom used in making technical decisions about operational equipment. In a relatively large number of cases, local firms played no role in the specification of the equipment to be acquired.

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[65] For example, in nine of the case study firms the choice of equipment was made subsequent to a trip abroad by the entrepreneur to observe the machinery.

[66] Even in cases where some type of feasibility studies are required by banks as prerequisite to applications for credit, it is often the entrepreneur who carries out the exercise.

Table 6.9
Kenya — Attributes of Major Investments
(Percent of Firms)

Firm Size	*Year of Investment*			*1990-92 Investment in Capital Stock (Mean Value)*		*Purpose of Investment*						*Technical Adaptation*	*Cost Change*		
	0-5	5-10	>10	All Firms	Investing Firms Only	1	2	3	4	5	6		Higher	Same	Lower
<10	82	8	10	12	18	23	56	3	5	8	5	13	29	47	24
10-49	72	11	17	10	13	33	29	0	0	33	5	18	18	41	41
50-99	83	10	7	7	8	18	50	18	4	4	7	25	17	39	43
100+	87	11	2	9	9	23	35	19	4	11	8	12	14	33	52

Note: Year of investment 0-5 means in the last five years; 5-10 means in the last 5-10 years, and >10 means more than 10 years.

Investment/Capital Stock = Value of investment in the 1990-92 as a percent of replacement cost of capital stock.

Purpose of Investment:
1 = Produce the same product but improve process
2 = Produce the same product but add to capacity
3 = Introduce new products
4 = Produce a different variety of a similar product
5 = Replace old equipment with similar equipment
6 = Other

Technical Adaptation: = Firms that carried out technical adaptation to the equipment.

Cost Change = Impact of new equipment on cost of production of unit of output.

Source: RPED Survey Data, 1993. Total observations=180.

Installing Equipment

As may be expected, virtually none of the firms in the case study reported starting up without experiencing some technical problems. The most frequent problem, cited by almost a third of the firms, was equipment breakdown, followed by failure to reach design capacity (26 percent of cases), problems achieving product and process specifications, and a high proportion of rejects. The problems were minor in many cases and were solved through experimentation, technical support or training of the personnel. Two firms reported that their equipment breakdowns were due to electric power supply problems which led them to install their own generators. In six extreme cases, the technical problems could not be solved which resulted in a reduced range of activities or outright replacement of the equipment.

A large proportion of the case study firms (42 percent) needed outside help in commissioning the physical plant. The outside help was provided primarily by the supplier of the equipment or the foreign partner/parent of the firm. Thus, ten firms stated that the supplier's personnel came to install the equipment while in five cases the firms' personnel were trained at the supplier's location and then sent back. The staff from the foreign partner, international headquarters or foreign licenser installed the equipment in four cases, while in one firm the technical representative of the supplier provided assistance and help in ongoing maintenance. In only one instance was local technical help utilized by the sampled firms. Thus, although external help was required in many cases, very little use was made of local engineering companies to help in the installation and commissioning of new plant or equipment. The infrequent use of local engineers is attributable to their scarcity, perceived high price for their services or their lack of experience with the foreign technology being imported.

Production Capabilities

Production capabilities of firms can be considered under two broad categories, namely, product technologies and process technologies. Product technological capabilities include improvements in product design or the introduction of new product designs. Process technological capabilities, on the other hand, refer to plant design and the layout of the production line, quality control, maintenance and repair, and industrial engineering.

Product Technologies

The ability to produce according to own design may be more important in some industries (such as textiles) than in others (e.g., beverages). In most of the firms surveyed in the case study, however, the design of the products was of local origin. In more than half the cases, the product was copied from a similar, locally produced product, indicating a great deal of emulation among the manufacturers. In another 30 percent of the firms, the product design was generated in-house by the manufacturer in accordance with local specifications. Product design in the remaining cases was attributable to foreign specifications, imitating imported products and customer-specified designs.

Almost half the firms in this sample claimed to have introduced a new product in the past five years, an overwhelming majority of which were developed in-house (including at headquarters or the holding company). Further, a similar proportion of firms reported introducing some changes in their product designs, although only a few such changes were substantial in nature. In the case of food products, for example, modification on a country-by-country basis of the recipe of a branded processed food, such as a breakfast cereal, is an important element of business strategy for the MNC food processors. Similarly, a wood product may be adapted to local climatic conditions and locally available woods. Indeed, in almost half the reported cases, the main reason to change a product design was to make use of locally available raw materials or to modify to suit local taste or climate. The remaining changes in product design were motivated by the desire to differentiate or diversify, simplify the product, to reduce costs, and to meet national product standards.

Changes in the product may entail modifications to the production process also. There were 23 process technical changes reported in the sample, about evenly distributed across all sectors except textiles which had only 1 such case. The most common changes were the manufacture of new tools, fixtures or machines (33 percent of all changes) followed by changes to save energy and to adapt to local raw materials.

Process Technologies

With the exception of firms in the food processing sector, a large number of firms in the other three sectors showed poorly-kept plant facilities. The difference in the food processing sector may be attributable to the stricter government regulations governing the licensing of production in such firms. Machinery and equipment tended to be old in a number of cases and sometimes poorly maintained. The vast majority of the firms in the case study survey were operating only one shift and the self-reported rates of capacity utilization fell below 75 percent for 80 percent of these firms with almost a third reporting utilization rates below 50 percent.

Technical Adaptation: Since the equipment used by firms is mostly of foreign origin or old, or both, firms may need to undertake technical adaptation of their equipment to suit their specific needs or objectives. The ability to carry out such technical adaptation would constitute an important element of the firm's process technological capabilities.

Table 6.9 reported the percentage of firms that undertook technical adaptation in the context of their last major investment in plant or equipment. The proportion of such firms increases from 13 percent for microenterprises to 25 percent for medium-sized firms and falling to 12 percent for large ones. It is difficult, however, to interpret these figures since it is not known how many of the firms not undertaking technical adaptation did not need to do so. For example, one could argue that the low figure for large firms reflects their ability to identify and finance the purchase of the appropriate machinery without needing to modify it. These figures do highlight, however, the relatively high levels of technical adaptation carried out by medium-sized firms. Although not reported in the table, the maximum proportion of firms carrying out technical adaptation of their equipment were in the metal working sector.

Troubleshooting, Maintenance and Repair: An important element of firms' technological capabilities is the extent to which they can cope with problems that arise in keeping the equipment running in an efficient manner and undertake effective repair and maintenance functions. Equipment breakdown was the most important operational problem reported by firms in the case study, with more than half the sampled firms citing it as a problem (See Table 6.10). The high frequency of equipment breakdowns is not unexpected in view of the relatively old age of the equipment. However, in several cases, the respondents mentioned electric power supply as contributing to the frequent breakdowns. Among other problems frequently cited by these firms were process imbalances, safety and difficulty in meeting orders.

Table 6.10
Kenya — Frequency of Troubleshooting Problems Reported
(Proportion of Case Study Firms Citing Specific Problem; Multiple Answers Allowed)

Problem	*Frequency*	*Percent*
Equipment breakdowns	19	54.3
Process imbalances	10	28.6
Safety problems	8	22.9
Difficulties meeting orders	7	20.0
Problems obtaining materials	4	11.4
Serious quality problems	3	8.6
Pollution control problems	2	5.7
Other problems	8	22.9

Note: Most of the items cited under "Other Problems" were related to electric power supply. One firm complained of a power failure and consequent fire, another of power cuts, a third of power supply limitations, and a fourth of electrical wiring problems. There were also complaints of poor quality castings, skilled labor scarcity, and poor road conditions (excessive dust) creating an environmental hazard.

Source: RPED Case Study Data, 1993.

Unlike the case of installation and commissioning of plants, most firms in the sample are well equipped for routine problem-solving. Thus, of the 63 troubleshooting experiences reported by the firms, in 36 (57 percent) cases the problems had been solved, and were in the process of being solved in another 8 cases. Only in 4 cases was no satisfactory solution reached.[67] In more than 80 percent of the solved cases, the task was completed by in-house personnel. In other cases, some local outside help was utilized and in only two cases did the firms use foreign help. A similar picture emerges in terms of the capacity of firms to undertake routine repair and maintenance of their plant and equipment. Almost 75 percent of the firms reported having qualified personnel in-house to carry out repair and maintenance work. The firms that do not have such capacities are, not surprisingly, the smaller ones in the sample. The food processing sub-sector showed relative superiority in this context with 8 of 9 firms having such specialized staff while only half the firms in wood working had such personnel. However, despite the existence of specialized personnel, only 13 firms in the sample reported formal

[67] No information was available for the remaining 15 cases.

procedures for *preventive* maintenance, i.e., maintenance activities scheduled at fixed points in time even when machines are running without experiencing breakdowns or need to replace parts.

Overall, therefore, firms in the case study sample appear reasonably capable in terms of routine repair and maintenance activities. Almost one-third of them are able to carry out simple tasks such as oiling and the replacement of belts and similarly accessible parts. The remaining two-thirds of the firms are also able to strip most of the machines and replace standard parts. Only one firm in the sample was totally dependent on outside help, although a majority of the firms contract out some specialized tasks like welding, electrical repairs, casting of spares, repair of motors, and fixing of electronic controls. Across sectors, metal working and food processing show superiority in these aspects of process technological capabilities relative to the other two sectors. The ability to carry out maintenance tasks is enhanced in the metal working establishments due to the nature of the labor skills and the equipment they utilize in production, both of which are quite similar to those typically required in mechanical repair and maintenance tasks.

Quality Control Systems: A third of the case study firms have a comprehensive quality control system encompassing the inputs used, materials in process, the processes and the final product, while 20 percent of the firms have no systems for quality control. Most firms the sample have some form of inspection of the final product as seen in Table 6.11. A smaller proportion of firms carry out quality control of raw material purchases, production processes or materials in process.

Table 6.11
Kenya — Existence of Quality Control and Its Level

Existence of Quality Control for:	*No. of Firms*	*Percent*
Final product	27	77.1
Processes	14	40.0
Purchases	20	57.1
Materials in process	15	42.9

Source: RPED Case Study Data, 1993.

The nature of the quality control systems does not appear to be very sophisticated in the sampled firms. Less than half these firms acknowledged the use of national or international product standards and the majority of them apply "practical," largely visual, inspection methods. Very few firms carry out control measurements or lab tests to verify compliance with norms or specifications (see Table 6.12). There is also virtually no existence of statistic quality control although a large state-owned textile mill had been using such statistical methods when it was a joint venture with Japanese investors. Site visits showed old charts still lining the wall and a discontinuance of these quality control measures. The firm ceased to exist soon after the case study survey.

Table 6.12
Kenya —Overall Quality Control System in Case Study Firms

System	*Frequency*	*Percent*
No system	7	20.0
Visual, practical inspection	18	51.4
Lab tests, standards	10	28.6

Source: RPED Case Study Data, 1993.

Across sectors, food processing and metal working show a greater emphasis on quality control mechanisms which may be attributed to health regulations and licensing requirements in case of former and technical reasons in the latter case. Six of the nine food processing firms were using national or international standards and four of them had "technical" (quality control) systems , i.e., having labs and conducting tests applying formal quality standards. A significant proportion of metal working firms (5 of 12) also use standards. In contrast, only 2 firms in each of the other two sectors use product standards in their operations.

Although the standards of quality control do not appear sophisticated overall, many firms in the case study reported improving quality trends over the last 5 years as reflected by self-reported figures of internal rejection rates (see Table 6.13). Needless to say, these figures are based on subjective assessments in many cases and could reflect the biases of the respondents. On a comparative basis, however, the sub-sector with the highest reported internal rejection rates is metal working, and that with the lowest is food processing. Public health regulations and strict controls on the production process may explain the performance of the food sector which is the most process-centered industry across all groups. Another relevant factor in this context may be that the precision requirements tend to be higher for some metal working products than those in other industries, and Kenyan manufacturers, due to lack of skills and adequate equipment, are having a harder time meeting those requirements. For example, one firm in the case study (manufacturing brass padlocks) has a high a rejection rate on its products. However, rather than determining the endemic cause, the firm has its craftsmen repair and kluge the defective units until they achieve a zero rejection rate.

Table 6.13
Kenya — Rejection Rates by Industry in Selected Years
(Percent)

Industry	*1988*	*1990*	*1992*
Food	3.3	1.7	1.6
Textiles	7.5	3.0	3.2
Wood	8.0	5.5	3.0
Metals	7.8	7.5	4.1

Source: RPED Case Study Data, 1993.

Industrial Engineering: Industrial engineering can usefully be applied to improve the productivity of plants in any industry. The technology case study interviews made it evident, however, that many of the Kenyan firms are not familiar with the concept. While they organize their thinking around production or output targets, they are not, for the most part, measuring the amount of output obtained in relation to the quantities of inputs utilized. Only one firm claimed to be engaged in a continuous effort to improve plant productivity and had assigned a university graduate towards this task on a full-time basis. A number of other firms professed to have a permanent interest in improving plant productivity but their efforts were sporadic and no one was assigned responsibility for this function. In most cases, the firms were also not aware of how their productivity compared with that of other firms in the same industry; larger, successful exporters were an exception. Furthermore, a very small numbers of firms acknowledged using production standards although none applied work study methods to establish them.[68]

Finally, although most firms carried out some form of advance scheduling of production and inventory control of raw materials, these tasks are performed at a fairly low level of technological sophistication. In general, control of raw materials is observed more frequently than other kinds of inventory control and control of final products is more common than control of work-in-progress inventory. Additionally, production planning and inventory control were generally not integrated and less than one-fourth of the firms use computers in this process. The firms in the case study displayed sectoral differences in methods of scheduling and inventory control related to the specific production cycles of different manufacturing activities. Scheduling in the metal working and wood working sectors reflects the focus on "delivery scheduling," stemming from "work to order," while the production-run sectors, such as food processing and textiles, work on the basis of forward planning.

Learning Mechanisms

The preceding description of the investment and production capabilities of the firms provides a summary descriptive analysis of the *levels* of technological capabilities in Kenya's manufacturing sector. An equally important set of issues relate to the dynamics of such capabilities: specifically, the nature of various linkages and learning mechanisms that can allow firms to increase the levels of their technical capabilities. The subsequent discussion follows the conceptual framework discussed in an earlier chapter by focusing separately on learning mechanisms that are internal to the firms, and private or collective mechanisms outside the firms.

Internal Sources of Learning

Learning-by-doing is well recognized as an important determinant of firms' technological capabilities, efficiency and production as they evolve over time. There are

[68] An implication of this finding is that there could be little connection between salaries paid and actual performance, at least from the viewpoint of the information requirements for quantitatively based incentive remuneration schemes.

various learning mechanisms internal to the firms which can enhance their ability to learn by doing. Three such mechanisms that were found in the case study survey are discussed, namely, job training within the firms, the organization of technological knowledge and functions within the firms, and efforts at research and development.

On-the-Job Training. Training, in principle, should not be confined to newly-hired workers alone. Technological developments occur continuously, demanding that technical training not be limited to the operative personnel but include also the supervisory and other technical and managerial personnel in the firm. The importance of worker training is recognized by Kenyan firms since a vast majority of the case study firms believe on-the-job training to be a prerequisite to operation of plant equipment. However, the firms offer widely divergent estimated durations for such training. This is attributable to the fact that the specific training entailed would depend upon the nature of the task, prior education and experience of the worker and the type of technology utilized by the firm.

A substantial number of the sampled firms also sponsor technical training for their middle-level technical personnel. These courses lead to a degree, a certificate or diploma, and they last for two years or more. Firms also pay for training of their middle-level technical personnel in two other areas: management and computers. In the case study sample, studies for the technical degrees were undertaken at the Kenya Polytechnic and Mombasa Polytechnic, with some others training at the Kenya Industrial Training Institute. The management and computer courses were undertaken at the Kenya Institute of Management and other private, local outfits. Regarding training for the professional personnel in these firms, only four cases were found in the case study. This may be due to the low number of professionals employed in industry (see Table 6.17 below). The training for professional personnel was focused on quality control, computers, accountancy, and observation of plants abroad.

Table 6.14 provides estimates for formal training inside and outside the firm based upon the larger RPED survey. A sub-sample of workers in each firm was asked about whether they were receiving formal training inside or outside the firm at the time of the interview. Since only a few of them were new recruits, these training figures are likely to represent formal on-the-job training in addition to the training imparted at the time of hiring. This applies in particular to data on training outside the firms.

As can be seen from the table, the prevalence of formal training, both inside and outside the firm, generally increases with the firm size. There is much less inter-sectoral variation with the exception of the higher incidence of external training in wood working firms and the lower incidence of internal and external training in textile and garments firms.

Table 6.14
Kenya —Training for Shop-floor Workers by Firm Size and Sector
(Percent)

	In-house	*External*
Firm Size (No. of Employees)		
<10	3.3	0.9
10-49	2.3	2.8
50-99	2.1	6.1
100+	6.0	6.8
Sector		
Food	3.7	4.0
Textile and Garments	2.2	3.7
Wood working	3.8	6.1
Metal working	4.1	4.1

Source: RPED Survey Data, 1993.

Organization of Technical Knowledge and Functions. The general level of technological organization in the activities of the firms in the case study did not show much sophistication. For example, the survey looked at the use of technical documentation which can help disseminate technical know-how among employees. However, a great deal of the technical know-how present in the manufacturing establishments visited by the case study survey had not been spelled out in written instructions. Specifically, three of the nine food processing firms, three of six textiles firms, two of eight wood working firms and two of twelve metal working firms had no written documentation.[69]

The firms were also asked about the existence of six different technical offices: product engineering, manufacturing or process engineering, quality control laboratory, industrial engineering, R&D, and pilot or experimental plan. Technical offices were found most often among the large firms, two-thirds of which were wholly or partly foreign or state owned. Quality control laboratories were the most frequently found technical office among the firms. Across sectors, food processing had the highest incidence of technical offices while no firm in wood working reported a major technical office. Overall, as seen in Table 6.15, more than half the case study sample did not have a single technical office — along with little or no written documentation of technical information.

[69] For those undertaking it, the modes of technical documentation mentioned by firms were manuals, quality control specifications, process charts, formulae (food processing), catalogues/client designs and drawings (wood-working and metal-working), and, casting patterns/assembly codes and instructions/blueprints (metal-working).

Table 6.15
Kenya — Distribution of Firms by Overall Level of Technological Organization

Level	*Frequency*	*Percent*
No documentation or technical office	17	48.6
Little documentation but no technical office	8	22.9
Some documentation and one or two offices	7	20.0
Good documentation and one or two offices	2	5.7
Good documentation and at least three offices	1	2.9

Source: RPED Case Study Data, 1993.

Research and Development. Table 6.16 shows the expenditure on formal research and development undertaken by all firms in the RPED panel survey. Only 14 firms, or 6.4 percent of the total, report R&D expenditures. The amounts spent are also quite low, ranging from 0.12 percent of sales for textiles sector, the highest, to 0.5 percent of sales for metal working firms. The total amount spent by all the firms amounted to US$189,000. Clearly, formal R&D is of limited importance in the expenditures of the firms.

Table 6.16
Kenya — R&D Activity by Size, Sector and Expenditures

Firms Doing R&D in each Size Class		*Firms Doing R&D in each Sector*		*R&D as a Percent*
No. of Employees	*Percent*	*Sector*	*Percent*	*of Sales (by Sector)*
<10	0.0	Food	5.8	0.07
11-99	3.7	Textile	3.5	0.12
50-99	12.2	Wood	6.7	0.07
100+	25.5	Metal	9.3	0.05

Source: RPED Survey Data, 1993.

Aside from formal R&D efforts, the internal learning capacities of firms may also be positively related to the presence of scientists, engineers and technicians employed by the firms. This employment is shown in Table 6.17. The metal working sector shows the highest proportion of engineers and technicians while the highest proportion of scientists are employed in the food and beverages sector. The latter may be reflecting the quality control requirements of the industry and also, to some extent, the use of chemists instead of chemical engineers — a largely absent engineering specialty in Kenya. In general, however, the overall proportions of scientific and technical personnel in the work force of the sampled firms are quite low in comparison to those observed in the manufacturing industries of other industrializing countries such as Korea, Taiwan or Mexico. Furthermore, in addition to low average levels, the employment distribution of scientists and technical personnel in the Kenyan firms is also strongly skewed with more than 40 percent of the employees in each category being employed by just three firms (see Table 6.18).

Table 6.17
Kenya — Employment of Scientists, Engineers and Technicians by Sector

Sector	*Total Employment*	*Scientists* *No.*	*Scientists* *%*	*Engineers* *No.*	*Engineers* *%*	*Technicians* *No.*	*Technicians* *%*
Food	6,173	21	0.34	18	0.29	157	2.54
Textiles	6,308	3	0.05	22	0.35	57	0.90
Wood	8,400	8	0.10	18	0.21	69	0.82
Metal	5,720	7	0.12	140	2.45	362	6.33
Total	26,602	39	0.15	198	0.74	645	2.42

Source: RPED Survey Data, 1993.

Table 6.18
Kenya — Concentration in Employment of Scientists, Engineers and Technicians

Personnel	*Total No.*	*No. of Employing firms*	*No. Employed by Three Largest Employers*	*% of Total Number*
Scientists	39	15	18	46.1
Engineers	198	52	85	42.9
Technicians	645	63	270	41.9

Source: RPED Survey Data, 1993.

Finally, like the scientists and technicians, another element of organizational human capital conducive to enhancing internal learning mechanisms is the presence of expatriate personnel in the firms. The use of expatriate personnel is quite common in Kenya with almost 30 percent of the firms in the RPED survey reporting their employment. Not surprisingly, the hiring of expatriates is related to firm size, with 82 percent of the hiring firms being large in size. Data on the hiring of expatriate personnel is summarized in Table 6.19 below.

Table 6.19
Kenya — Use of Expatriate Personnel by Firms in Panel Sample

Sector	*Firms*	*Expatriates*
Food	12	34
Textile	14	66
Wood working	15	27
Metal working	21	120
Total	62	247

Source: RPED Survey Data, 1993.

The metal working sector is relatively the most active in such employment, accounting for almost a third of all firms that hire expatriate personnel and almost half of all expatriates employed in the sample. Almost 52 percent of the expatriates were employed in technical positions while another 46 percent were in managerial positions. The proportional division between technical and managerial assignments was roughly even in the food processing and wood working firms. Expatriates were hired primarily as managers in textiles firms while in the metal working firms it was the reverse, with two-thirds of the expatriates in technical positions.

External Sources of Learning

In principle, two types of external learning mechanisms can contribute to firms' enhancement of their technological capabilities: private mechanisms, stemming from interactions with the firm's buyers and suppliers and the inter-firm spillovers of knowledge from the vertical and horizontal links, and collective mechanisms. Collective learning mechanisms, in turn, can be of two different forms, namely, the existence of an "information-rich" environment or firm-specific "high-intensity" technological support through, for example, formal technology transfer agreements and sustained joint work with specialist technology institutions. Each of these are discussed at length in the conceptual methodology (Chapter 1) earlier. Here, the manifestation and scope of different learning mechanisms are the issues, specifically in the case of the Kenyan sample of firms.

One notes at the outset that data from the two RPED surveys indicate that the different channels of external learning mechanisms are anemic at best and should be an area of considerable policy concern. To begin with, high-intensity technological support is virtually absent among the sampled firms. Other collective mechanisms are also tenuous due to the deficiency in the ability of the government and the private sector to provide a reasonably information-rich environment for the firms. Finally, even the inter-firm spillovers of knowledge have a limited flow, being confined for the most part to suppliers of equipment and parent companies of foreign owned firms.

Private External Mechanisms: Transactions with Buyers and Suppliers and Inter-firm Linkages. It was noted earlier that most firms had undertaken some form of product modification, a few of which were major in scope. Data from the case study survey show that in 23 percent of the cases, product development was based upon customer specified designs. This is a far cry from the type of linkage mechanisms seen in other countries, in East Asia for example, where larger firms as customers would contribute substantially to the technological upgrading of the smaller, supplying firms. This is not surprising, however, given the low endowment of vertical inter-firm relationships in Kenyan manufacturing, which themselves are attributable in part to the large gaps in the industrial sector leading to import of most major raw materials. There is another important reason, however, that also contributes to low levels of subcontracting and vertical relationships among firms, namely, the inability of firms to exercise *control* over such relationships.[70] For example, the Kenya Subcontracting and Partnership Exchange (KSPX) was established in mid-1991 with UNDP and UNIDO funding to increase the extent of subcontracting among the firms in the economy. However, the implementation of this project has been slowed down by fear among the reluctant potential contractors that they could be building up their competitors.

There were only a few cases of subcontracting found in the case study firms, and a look at these arrangements highlights their difference from the vertical subcontracting links that potentially drive inter-firm spillovers of technological knowledge:

- During the period 1988-93, firm MW22 subcontracted out its electroplating services and tool and die making facilities to make use of its excess capacity and skilled labor.

- Technology case study firm MW23 produces about 40 percent of annual revenue from subcontracted orders for steel frames for school desks.

- Technology case study firm TG24 out-sources repairs and maintenance services among the Kenya Industrial Estate firms.

Tenuous vertical links among firms are also accompanied by the virtual absence of horizontal links wherein firms may be embedded in a network of firms engaged in similar activities. It was already noted, for example, that there is little or no awareness among the sampled firms of productivity levels in other firms that are their competitors.

The two main sources of external learning channels for these firms appear to be through the suppliers of equipment and the parent/partner companies of subsidiary/joint venture companies. The discussion of investment and process capabilities has already highlighted the training and technical assistance provided by the suppliers and partner/parent companies in the course of initial acquisition of technology and in the repair and maintenance of equipment. Thus, in 60 percent of the cases, the decision on initial acquisition involved a trip abroad, and in nine of ten cases where a supplier installed the equipment, plant personnel were provided specialized training either at home or at the supplier's location abroad.

Two other private external mechanisms are foreign licenses and technical assistance agreements, both oriented towards technology transfer. Their use is also quite limited with only 9 firms with foreign licenses and 17 with technical assistance contracts among the 214 firms covered in the panel survey. The metal working and food processing sectors are the largest users of these transfer channels. A majority of the firms holding licenses, or who were parties to technical assistance agreements, had foreign owners or were foreign joint ventures. These firms also constituted 42 percent of all the firms employing expatriate personnel in the panel sample. The extent to which technology transfer is resulting from these arrangements is not always clear as some illustrative examples indicate:

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[70] The close links between banks and business groups (like the 'grupos' or 'chaebol') can allow the use of debt as an instrument of control. Similarly, equity participation also allows shareholders to have control over the firm's assets and actions. Both these are mostly absent among the firms sampled in Kenya.

- Firm MW26 holds licenses from China to manufacture market-appropriate and branded kerosene lamps and stoves and is planning to add a Chinese license for enamelware.

- Firm MW12 owes its existence to the purchase of the Kenyan franchise to manufacture an international brand of locks. The licenser provided all technology, training and even plant layout.

- Firm FP38 is the local subsidiary of an international confectioner. With the opening of the market to competition, the manager is drafting plans to improve the plant's technology under the terms of the license with headquarters.

- Firm MW22 was founded as a joint venture between the Kenyan government and a former East Bloc government with a licensing arrangement. The license is virtually worthless now since the plant is not being supported operationally and the license is for a technology that will not be upgraded.

Collective External Mechanisms. External mechanisms that are collectively provided by the government, NGOs or donor programs can create an information-rich environment of institutional or private sources of training opportunities and information sources that address specific business problems as well as foster the availability of networks of specialized consultants. Although there are a number of collective institutions existing in Kenya, their success in creating an information-rich environment of direct use to the manufacturing sector appears limited.

According to the respondents in the case study survey, the external support services most used were, in order of frequency: repair and maintenance, calibration of instruments, technical assistance, quality control (including testing and certification), and personnel training. Metal working and food processing firms were more likely to seek technical support services than firms in the other two sectors.

These services were provided by various government institutions, except repairs and maintenance, for which firms mostly utilized local mechanics or engineering firms, and technical assistance for which local or international consultants or personnel from the headquarters or supplier were used. The Kenya Bureau of Standards (KBS) and the Kenya Industrial Research and Development Institute (KIRDI) were the major providers for instrument calibration. KBS was also a major source for quality control services. For training, the most frequent sources were the Kenya Polytechnic (in half the cases), the Kenya Textile Training Institute (KTTI), the Mombasa Polytechnic and the Kenya Industrial Training Institute.

However, the larger panel sample makes clear that most of these institutions are utilized only minimally by manufacturing firms in Kenya. As seen in Table 6.20 below, quality standards and training of personnel were the services most utilized by the panel firms, primarily from the KBS and the Directorate of Industrial Training, with little or no usage of services of the other industrial and technical support institutions.

Table 6.20
Kenya —Number of Firms Using Key Support Services by Firm Size and Sector, 1992

	Kenya Bureau of Standards	*Directorate of Industrial Training*	*Kenya Industrial Training Institute*	*Kenya Institute of Science and Tech.*	*Kenya Polytech.*	*Kenya Textile Training Institute*	*Kenya Industrial Research and Training Institute*	*Total*
Firm Size								
<10	5	0	0	0	1	0	0	6
11-50	17	6	2	1	0	0	1	27
51-100	16	7	2	0	1	2	0	28
101+	24	7	2	0	3	3	1	40
Total	62	20	6	1	5	5	2	101
Sector								
Food	25	5	0	0	2	0	1	33
Textiles	17	3	2	0	0	5	0	27
Wood.	4	7	1	1	0	0	0	13
Metal	16	5	3	0	3	0	1	28
Total	62	20	6	1	5	5	2	101

Source: RPED Survey Data, 1993. Sample Size is 223 firms.

The fact that most firms do not utilize many of the state-provided institutions appears more a reflection of poor quality of their services than absence of need on the part of firms for the services that *could* be provided by the institutions. This is suggested by the responses of firms in the case study to questions regarding their desired support services: they were asked to indicate specific services desired and then to rank their interest in that service on a scale of 1 to 5. The results are summarized in Table 6.21.

Clearly, the support services most desired by the firms reflect basic concerns with capital equipment and human resources. The most desired support service is employee training, closely followed by assistance with repair and maintenance, and productivity techniques. Other areas ranked important by firms are quality control testing and assistance with tools, dies and fixtures. Across sectors, most metal working firms (9 of 12) expressed interest in personnel training services as well as the manufacture of tools, dies and fixtures (9 of 12). In the food processing firms, the most desired services were for repair and maintenance (5 of 9 firms).

Table 6.21
Kenya — Highly Desired Support Services

	No. of Firms Interested	*No. of Firms Ranking It*	*Weighted Rank*
Employee Training	19	16	2.48
Repair and Maintenance	14	13	2.08
Productivity Techniques	14	13	1.95
Tools, Dies and Fixtures	15	11	1.68
Quality Control Testing	16	11	1.45
Troubleshooting Assistance	9	8	1.17
Labor Relations	9	6	0.92
Energy Saving	9	6	0.88
Safety	11	6	0.86
Process Improvement	10	5	0.60
Product Design	7	4	0.56
Pollution Control	5	2	0.30
Pilot Plant Experimentation	2	1	0.07
Instruments Calibration	6	0	0

Source: RPED Case Study Data, 1993.

7. Technological Capabilities and Learning: Ghana

Background to Technological Development

Modern manufacturing has had only a brief history in Ghana, which before independence in 1957 was a colonial economy based on primary goods production and export of natural resources.[71] After independence, the government launched an import substitution strategy which, in part due to the absence of an indigenous entrepreneurial class in manufacturing, led to a leading role of the public sector in the economy. The period since then can be broadly summarized as one of macroeconomic stability and strong growth rates in the first half followed by worsening macroeconomic imbalances and negative growth rates in the economy.

In 1983, the new government at the time initiated a comprehensive set of economic reforms under the Economic Reform Program (ERP). Ghana is viewed as one of the early and most successful implementers of the economic liberalization and economic restructuring policy reforms implemented all through the Sub-Saharan region during the previous decade. The key changes have been a steady devaluation of a long overvalued exchange rate, liberalization of trade flows, a steady move towards privatization and relaxation of government controls, and restrictive monetary and fiscal policies. Ghana has received substantial international assistance during the ERP and is considered noteworthy for having implemented reforms of the structural adjustment programs to a much greater degree than is the case with most other Sub-Saharan economies. However, the performance of the economy, and the manufacturing sector in particular, has been unsatisfactory during this period, an issue we turn to next.

Structure and Performance of Ghanaian Manufacturing Sector

Table 7.1 shows the size distribution of firms in Ghanaian manufacturing along with the associated employment figures. The data are from an Industrial Census undertaken in 1987 and show that although the number of smaller firms in the economy is larger, the proportion of formal employment accounted for by the larger firms is much higher. However, data on the number of people employed in small firms, i.e., those with employment less than thirty, is quite likely an underestimate. According to the Population Census in 1984, there were as many as 530,000 people employed in small firms. Even if the actual figures on the number of small firms and their employment are somewhere in between these widely disparate numbers, the data clearly indicate that the typical scale of activities in Ghana in terms of firm size is small, especially in comparison to the other two countries included in this study. The formal manufacturing sector shows three broad groups: a few

[71] This chapter is based upon field work conducted in Ghana in 1992 by RPED consultants Sanjaya Lall, Giorgio Barba Navaretti, Simón Teitel and Ganeshan Wignaraja, as well as their collaborators, Seth Adoo and K.A. Nuhu of the Ghanaian Ministry of Finance. The results of this work were published as: Lall S., G.B. Navaretti, S. Teitel and G. Wignaraja, 1994. *Technology and Enterprise Development: Ghana Under Structural Adjustment.* New York: St. Martin's Press.

large and medium sized firms that constitute the modern sector, a larger population of small firms perhaps using some modern technology, and a large number of informal or microenterprises mostly using simple and traditional techniques in their operations.

Table 7.1
Manufacturing Industry in Ghana — The 1987 Industrial Census

Firm Size (No. of Employees)	*No. of Workers*	*Establishments*
1-4	7,400	2,884
5-29	42,805	4,802
30-99	21,710	423
>100	85,169	242
Total	157,084	8,351

Source: Central Bureau of Statistics, 1987, *Industrial Census*. Government of Ghana, Accra.

Prior to independence, the medium and large-scale industrial sector in Ghana was dominated by wholly foreign-owned enterprises. Only 40 percent of these firms were owned indigenously in 1962, while 50 percent were foreign owned and the remaining firms were joint ventures. The proportion of wholly foreign owned firms has declined over time. In 1982 they represented 2.5 percent of all firms, although almost 40 percent of the firms were jointly-owned by foreign and Ghanaian investors. Even now, the modern sector appears to be concentrated in food processing and industries making industrial intermediates, and is largely owned by foreign interests, government or local non-Africans. It has strong technological connections with foreign companies, regardless of ownership, but very little with the domestic economy.

Industry contributed almost 14 percent of the GDP in Ghana during the period 1984-90 in comparison to 22 percent in the period 1967-71. The corresponding figures for manufacturing alone were 9 percent and 14 percent. Nearly half the manufacturing value-added in Ghana is accounted for by beverages, tobacco products and petroleum refining. The share of the four sectors included in this study in manufacturing value-added was the same in 1986 as in 1962, namely 40 percent, while the share in manufacturing value-added was also the same at roughly 70 percent. The static picture yielded by these numbers is attributable to the fact that the initial years of growth after independence were followed by a sustained period of industrial decline. Thus, by 1984, manufacturing output in Ghana was 39 percent of the level achieved in 1977 and capacity utilization was down to a mere 18 percent. The share of manufacturing to GDP had dropped from a peak of 14 percent in 1975 to 4 percent in 1983 (World Bank 1991b, and Lall and others 1994). Although manufacturing value-added grew at double digit rates of growth in 1984-87, it subsequently slowed down until 1990 when the total manufacturing production was still only 63 percent of its level in 1977.

The performance of Ghanaian exports reflects further on the level of development of its industrial sector. Total manufactured exports in 1986 amounted to only US$3.5 million.

Although the exports increased, following the ERP, to US$14.7 million by 1991, the growth came mainly from resource-based industries that were already established in the export markets. The main performers in non-traditional exports were wood products and aluminum which together accounted for more than 75 percent of the total (US$6.2 million and US$5.5 million respectively). Aluminum exports are accounted for by two long-established foreign firms, while one Scandinavian firm alone accounts for around 95 percent of furniture exports from Ghana.

Physical and Human Capital and Science and Technology in Ghana

Before discussing the technological capabilities of the surveyed firms, it is useful to briefly evaluate the aggregate stock of the primary factors of production in the economy, i.e., labor and capital, as well as of the level of scientific and technological activities available to the industrial sector.

Labor

By Sub-Saharan African standards, Ghana has a well-deserved reputation for possessing a large base of skilled labor. The enrollment ratios in primary and secondary schools rose through the 1970s and 1980s and Ghana ranked higher in 1965 and 1985 in secondary school enrollment than all the other countries in the region except Zimbabwe and Mauritius. Tertiary education has an enrollment ratio of 2 percent, which is low by international standards but on par with the regional average, (see Table A-1 in Appendix A). It is also useful to supplement these figures with data on tertiary level enrollment in technical subjects that are likely to be of direct relevance to technological capabilities in industry: general science, natural science, mathematics, computing and engineering, and engineering only. The proportion of enrollments to population in the category 'natural sciences, mathematics, computing and engineering' comes to 0.01 percent in Ghana, the same as in Zimbabwe and slightly less than in the other four African countries shown in the table. This can be compared to 0.76 percent in South Korea (See Table A-2 in Appendix A). Finally, Ghana's enrollment figures for vocational training are shown in Table A-3 in Appendix A. Ghana fares relatively worse than most other countries in a region that lags behind the averages for industrializing countries in other parts of the world. Finally, we can note, at a lower level of disaggregation, the trend in engineering graduates at the University of Science and Technology in Kumasi, the only university in the country granting engineering degrees. Although the number of engineering graduates has gone up from 125 in 1984 to 193 in 1991, the percentage of graduates in manufacturing-related subjects (chemical, electrical, electronic, and mechanical engineering) has fallen from almost 49 percent to 39 percent. A similar decline is also seen in the number and proportion of engineering diploma holders.

Capital

The age of the capital stock can provide some indication of the modernity of techniques in use, although it is possible to buy new machines embodying old technologies.

To that extent, a description of the base condition of the country's capital stock can provide a useful context to the assessment of technological capabilities in the manufacturing sector.

Lacking adequate aggregate data on capital stock, this study uses data on age of machinery and equipment from the random sample of firms visited in the RPED survey. Almost all manufacturing equipment used in Ghana is imported, a fact reflective of the absence of a strong capital goods industry in the country. Almost half the sampled firms had begun operations by buying second-hand equipment. The average age of the principal machinery used by the firms in Ghana is high, equaling 21 years. More than 40 percent of the equipment of medium-sized firms, with employment ranging from 51 to 100 employees, is older than 20 years. Across the sectors, almost half the equipment of firms in all sectors except food processing was less than 10 years and almost a third ranged from 11-20 years in age.

Science and Technology

The level of scientific and technological development in the economy constitutes an integral element of the infrastructure supporting industrial manufacturing. In light of the preceding discussion of the low rates of enrollment into advanced science-related studies, it would be reasonable to expect a meager stock of trained scientists and engineers and low levels of scientific and technological activities in Ghana. This is clearly manifested in the nature and scope of research and development (R&D) activities undertaken in the country and is briefly discussed here.

Practically all industrial R&D in Ghana is conducted by public institutions rather than firms. Accurate data on aggregate R&D are not available but some estimates show R&D expenditures in Ghana as equaling 0.1-0.2 percent of the GDP in 1983-87.(Moore 1989) These figures are down from around 0.7 percent of GDP in the mid-1970s and are quite low in comparison to other developing countries outside of Sub-Saharan Africa. The aggregate R&D figures also include substantive components for activities related to agricultural research, but in Ghana the institutions responsible for industry-related R&D can be identified. These are three bodies of the Council for Scientific and Industrial Research (CSIR): the Industrial Research Institute (IRI), the Scientific Instrumentation Center (SIC) and the Food Research Institute (FRI). Their function is to develop and disseminate technologies for use in the manufacturing industry and to conduct contract technological work for industrial enterprises. In 1989, the three CSIR institutions together employed 282 people of which 45 were 'scientific' staff (degree holders in technical fields engaged in research) and 123 were technical support staff with diplomas. The total funding of the three institutes in 1989 was 239 million cedis (US$885,000) or approximately 0.02 percent of the GDP.

This suggests that the R&D effort in Ghana is quantitatively minuscule.[72] In addition to its small magnitude, there are also serious concerns regarding the quality and relevance of

[72] Two other institutions are responsible for the identification and diffusion of intermediate technologies for small and microenterprises. These are the Development and Application of Intermediate Technologies

the research. Many official reports also appear to indicate that much of the work carried out by the CSIR institutes is largely unrelated to the problems facing Ghanaian manufacturing enterprises and very little of the R&D results in commercial application. This is also reflected by the data on patents granted since 1960 to residents and non-residents in Ghana in Table A-6 in Appendix A. With an average of 58 patents per year, Ghana ranks lower than all other countries in the table except Uganda.

Characteristics of the Survey Data

The data for Ghana utilized in this study were obtained from two RPED surveys conducted in August and September 1992. The first was a comprehensive questionnaire devoted to a set of topics related to the firms' activities in product markets, labor and capital markets, general firm attributes, entrepreneurial attributes, technological capabilities, infrastructure and regulation.[73] This questionnaire was implemented for 200 firms chosen randomly from the four sectors: food processing, wood products, textiles and garments, and metal working, and were spread over the main areas of manufacturing activity in the country.[74] Of the original 200, a total of 36 firms could not be included due to missing or incomplete information leaving a total effective sample size of 164.

The main survey was supplemented by a case study of 32 firms chosen from the full 200-firm survey sample. The case study focused exclusively on issues related to technological capabilities of the firms and included, where appropriate, site visits to the plants and factories. It dealt with a host of qualitative and quantitative variables directed at the acquisition of technology, the nature of in-house technological activities, training programs, relationship with technical institutions and other mechanisms of internal and external technological learning by firms. The firms in the case study were chosen in a manner that would provide a mix of firms of different sizes and ownership forms and be of technological interest. A number of specific firms were also selected on the basis of prior knowledge of exceptional technological activity.

Unlike the main survey, firms in the case study were chosen only in Accra and Kumasi. Other summary attributes of the two surveys are provided in the subsequent tables. As can be seen from Table 7.2, both surveys contain roughly a fourth of firms from each sector of the study. Furthermore, given the relative insignificance of firms outside of Accra and Kumasi in the panel survey, the geographical location of firms in the two surveys does not appear very different (Table 7.3).

(DAPIT) and the Ghana Regional Appropriate Technology Industrial Services (GRATIS). The scale of operations of these institutions is very small.

[73] Subsequently, the survey has been undertaken for the same firms twice more, with a gap of one year between each round. Results from later rounds will be analyzed as and when they come in.

[74] For details of the sampling procedures used, see Regional Program on Enterprise Development (1993c).

Table 7.2
Ghana — Industry Composition
(Comparison of Case Study and Survey Samples)

	Food		*Textile*		*Wood*		*Metal*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	7	21.9	8	25	8	25	9	28.1	32	100
Survey	41	22.9	38	21.2	52	29.1	48	26.8	179	100

Source: RPED Case Study and Survey Data, 1992.

Table 7.3
Ghana — Location Distribution of Firms in Both Samples

	Accra		*Kumasi*		*Other*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	22	68.8	9	28.1	1	3.1	32	100
Survey	98	54.7	65	36.4	16	8.9	179	100

Source: RPED Case Study and Survey Data, 1992.

Both samples are also similar in terms of the ownership structure across the firms, (Table 7.4). Roughly 75 percent of the firms in both samples are private, Ghanaian-owned, while another 12 percent are owned by foreigners or are joint ventures.

Table 7.4
Ghana — Ownership Structure, Comparison of Both Samples

	Private (G)		*Private (F)*		*Private (G & F)*		*State & Private*		*State*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	24	75	1	3.1	3	9.4	3	9.4	1	3.1	32	100
Survey	141	78.8	4	2.2	21	11.7	5	2.8	8	4.5	179	100

Source: RPED Case Study and Survey Data, 1992.

The survey and the case study firms are sharply distinct in terms of the size distribution of the included firms. Only 12 percent of the survey firms are large with the remainder split between the medium-sized and small firms, (Table 7.5 below). This distribution reflects much more closely the structure of Ghanaian industrial sector compared to the case study sample which has only a handful (6 percent) of small firms and large firms constituting almost 38 percent of the sample. The size distribution of firms in the case study is in concordance with its focus on firm-level technological capabilities as defined in the conceptual framework earlier.

Table 7.5
Ghana — Comparison of the Size Composition of Both Samples

	Small		*Medium*		*Large*		*Total*	
Sample	*No.*	*%*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Case Study	2	6.2	18	56.3	12	37.5	32	100
Survey	72	40.2	85	47.5	22	12.3	179	100

Source: RPED Case Study and Survey Data, 1992.

Technological Capabilities and Learning Mechanisms: A Summary Evaluation

Investment Capabilities

The introduction of the ERP in Ghana in 1983 had improving the investment climate in the economy as one of its objectives. However, aggregate data from the National Statistics show relatively pallid success towards that end. Private fixed investment in the aggregate, which had hovered around an average of 3 percent of the GDP (at market prices) over the period 1978-83, had not increased substantially after the introduction of the reform program. Thus, private fixed investment as a percent of GDP at market prices was 2.1 percent in 1986, 2.5 percent in 1987 and 3.3 percent in 1988.[75] Although investment data for the most recent years are not available at an aggregate level, results from the large RPED survey can provide a representative picture of recent firm investment activity at a more disaggregated level. These figures, summarized in Table 7.6, display a relatively more mixed picture of firm investment behavior. Thus, 79 percent to 94 percent of the firms in different size classes report undertaking a major investment in their plant or equipment in the five years up to the survey undertaken in 1992. If the period is extended to ten years prior to the survey, at least 90 percent of the firms in each size class report undertaking such investments. At the same time, though, the size of these investments is not very large, equaling at most 10 percent of the replacement cost of their capital stock, except for microenterprises for whom the corresponding figure is 28 percent. If all firms, and not just the investing firms are taken into account, the mean value of investments to replacement cost of capital ranges from 2 percent to 10 percent. The most common objective of the last major investment reported by the firms was addition to capacity but it was followed, in importance, by the proportion of firms

[75] At the same time, though, public fixed investment in Ghana has increased dramatically, from an average of 2 percent of GDP over the period 1978-83 to more than 7 percent of the GDP over the years 1986-88. A fairly large proportion of the increased public investment has been financed from foreign savings which have increased much more than domestic private or public savings. See Regional Program on Enterprise Development (1993c).

seeking to improve their production process for producing the same goods. The latter ranged from 10 percent to 46 percent of firms according to size class of the firms. It is noteworthy, however, that the largest firms tended to be investing more in capacity expansion than process improvements while the others had a relatively more even distribution between expanding for capacity expansion versus process oriented investment. As the last column in Table 7.6 shows, the outcome of these investments for the firms that did undertake some improvements was a lowering in the unit costs of production in a significantly high number of cases.

It has already been noted that, in general, the outcome of firms' investment efforts depends critically on their investment capabilities. However, the relatively limited magnitude of firm-level investment activity in Ghana renders even more critical the firms' investment capabilities which determine the quality of these investments. Consequently, this study now turns to an assessment of these capabilities in terms of how firms identify the equipment and technology needed, find and acquire them, undertake installation and actually get into production. Needless to say, the appropriate investment capabilities vary by industry, the level of technology used, the scale of the operation and the nature of the intended market (local or foreign, niche or exposed to competition, etc.). Investment capabilities of the firms in Ghana are assessed here in the context of their initial acquisition of equipment and technology, i.e., at the inception of the firm, using data from the case study. The presumption is that similar capabilities would be brought to bear on subsequent investments by most of the firms. This is borne out by the responses of firms in the case study compared to sources of information utilized for their major investments implemented after start-up: of the 23 firms providing responses, *all but 4 had utilized the same sources as they did in their initial acquisition of plant and equipment.*

Initial Acquisition and Equipment Installation

Given the virtual absence of a large capital goods sector in Ghana, it is to be expected that virtually all machinery and equipment in manufacturing is of foreign origin. In general, there is a high propensity to start with used equipment which typically comes without the manufacturer's technical assistance, and for which spares may be difficult to obtain. Almost half of the case study firms started-up with used equipment: 15 relied exclusively on used plant and machinery while another 2 used a mixture of new and used equipment. For the larger sample of the RPED survey, Table 7.7 below shows selected attributes of the start-up investment by the Ghanaian firms. The proportion of firms indicating that their original equipment was either wholly or mostly foreign origin rises from 68 percent for the microenterprises to 100 percent for the largest firms. Part of the reasons for used machinery and equipment being so prevalent may attributed to the high proportion of firms indicating price as one of the major factors motivating their choice of equipment. The two other most important factors motivating choice of the start-up machinery in the sample are familiarity with equipment and its durability.[76] Finally, as might be expected, the proportion of firms

[76] The remarkably high proportion of microenterprises citing familiarity as the major factor underlying choice of equipment is also related to the fact that the most common source of information about machinery for them

requiring training to accompany the equipment and machinery purchased increased with the size of the firms: the larger firms purchasing mostly foreign machinery for more complex manufacturing activities are more likely to report incidence of training.

tend to be other local firms in the economy. This is discussed under "learning mechanisms" later in this chapter.

Table 7.6
Ghana — Attributes of the Last Major Addition or Change to Plant or Equipment
(Percent of Firms)

Firm Size	*Year of Investment*			*1990-92 Investment in Capital Stock (Mean Value)*		*Purpose of Investment*						*Technical Adaptation*	*Cost Change*		
	0-5	5-10	>10	All Firms	Investing Firms Only	1	2	3	4	5	6		Higher	Same	Lower
<10	87	4	9	10	28	46	46	0	0	8	0	0	10	50	40
10-49	79	9	12	5	10	30	37	10	0	23	0	14	4	65	31
50-99	79	21	0	2	7	29	29	0	0	29	14	43	0	33	67
100+	94	6	0	6	10	10	60	0	0	30	0	10	10	20	70

Note: Year of investment = 0-5 means in the last five years; 5-10 means in the last 5-10 years, and >10 means more than 10 years.

Investment/Capital Stock = Value of investment in the 1990-92 as a percent of replacement cost of capital stock.

Purpose of Investment:
1 = Produce the same product but improve process
2 = Produce the same product but add to capacity
3 = Introduce new products
4 = Produce a different variety of a similar product
5 = Replace old equipment with similar equipment
6 = Other

Technical Adaptation: = Firms that carried out technical adaptation to the equipment.

Cost Change = Impact of new equipment on cost of production of unit of output.

Source: RPED Survey Data, 1992.

Table 7.7
Ghana — Selected Attributes of Original Investment in Start-up Equipment
(Percent)

	Foreign or Mostly Foreign	*Training Required*	*Familiarity*	*Price*	*Durability*	*Others*
No. Of Employees						
<10	68	4	46	23	14	16
10-49	86	25	31	18	22	29
50-99	94	33	23	31	23	23
100+	100	77	44	17	17	22
Sector						
Food	60	36	58	10	7	26
Textiles & Garments	97	6	21	18	27	35
Wood	90	26	40	19	21	19
Metal	81	27	39	33	19	16

Source: RPED Case Study and Survey Data, 1992.

Since the case study sample is dominated by the larger firms, it allows us to probe further the investment decision of firms at start up. In the case study firms, the choice of the initial plant and machinery is based on sources that vary primarily with firm size. Smaller firms using simple technologies and basic hand tools are unlikely to undertake extensive search outside of local sources while the larger firms, with more complicated equipment and process needs, frequently rely on external sources for acquiring technological information. Thus, among the larger firms in the case study, only 10 firms relied on local sources while the other two-thirds of the firms utilized various types of foreign sources (see Table 7.8 below) As might be expected, the nature of technical assistance and training accompanying the firm start up also reflect the sources utilized in the initial acquisition of technology.

For example, firms that are subsidiaries of foreign firms inevitably rely on their parent companies for the choice of plant and machinery. Thus, three food processing firms — FP1, FP2 and FP7 — are MNC affiliates and relied exclusively on their parent companies for designing, procuring, setting up and launching their investments. Each of them had foreign technicians staying in Ghana for extended periods to train local employees. However, little or no information on design, detailed engineering of the process and selection of equipment appears to have been transferred to local personnel over the last 30-40 years that these firms have been in existence. In fact, while each of the MNC affiliates is planning or has set up new investments in response to the liberalization policies, all the technical investment functions are being handled by the parent company.

Table 7.8
Ghana — Investment in Plant and Equipment by Case Study Firms

Firm	New/Used Equipment	*Sources of Information for Initial Investment in Equipment:* Specific	General	*Major Subsequent Investments* Total value of major additions since 1983	Sources of Information: General
Textiles and Garments					
TG1	New	Local Dealer	L	1,729 (2)	FWS
TG2[a]	Used	Trade Fairs	FWS	n/a	n/a
TG3	New	Foreign Cloth supplier	FNS	n/a	n/a
TG4	Used	Own Search Abroad	FWS	n/a (1)	FWS
TG5	New	Foreign Agent	FWS	0	
TG6	New	Foreign Equip. Manuf.	FWS	0	
TG7	Used	None (Subcontracted)	L	0.3 (1)	
TG8	Used	Non (Subcontracted)	L	0	
Food Processing					
FP1	New	Foreign Parent	FNS	n/a	n/a
FP2	Used	Foreign Parent	FNS	600 (1)	FNS
FP3	New (TK)	Foreign Eng. Firm	FWS	191 (1)	FWS
FP4	Used	Own Search abroad	FWS	5 (1)	n/a
FP5[a]	New (TK)	Foreign Eng. Firm	FWS	0	
FP6	New	Foreign Parent	FNS	6 (2)	FNS
FP7[a]	New (TK)	Foreign Eng. Firm	FWS	2,000 (1)	FWS
Wood working					
WW1	New	Previous Work Experience	FWS	n/a (3)	FWS
WW2	New	Foreign Parent	FNS	n/a (1)	FWS
WW3	Used	Previous Work Experience	FWS	500 (1)	FWS
WW4	New	Foreign Embassy	L	0	
WW5	New & Used	Own Search Abroad	FWS	450 (1)	FWS
WW7[a]	Used	Previous Work Experience	L	2 (3)	L
WW8[a]	New & Used	Previous Work Experience	L	0 (1)	L
Metal working					
MW1	New (TK)	Foreign Eng. Firm	FWS	n/a	n/a
MW2	Used	Foreign Agent	FWS	172 (1)	FWS
MW3	New	Foreign Partner	FNS	n/a (1)	FWS
MW4	Used	Foreign Parent	FNS	18 (1)	FNS
MW5	Used	Work Experience	L	12 (1)	L
MW6	Used	Other Local Firms	L	3 (2)	L
MW7	Used	Education and Work Experience	L	8 (2)	FWS
MW8[a]	New (TK)	Government Purchase	FWS	12 (1)	FWS
MW9	Used	Other Local Firms	L	1 (1)	L

[a]Founded since 1983. TK = Turnkey Project. L = Local Sources. FWS = Foreign with search.
FNS = Foreign, no search.
Source: Lall, S., G.B. Navaretti, S. Teitel, and G. Wignaraja, 1994. *Technology and Enterprise Development: Ghana Under Structural Adjustment.* London: Macmillan.

Other, locally-owned firms use foreign engineering firms for more complex processes, particularly if purchasing new equipment, or rely on suppliers/local dealers of the foreign manufacturers. For example, a food processing firm, which was a turnkey project, opted for Italian equipment and located the suppliers through the embassy. As part of the contract, the firm negotiated a ten-year guarantee and four years of technical assistance consisting of four Italian engineers stationed locally, as well as regular visits by special technical teams. Similarly, initial start-up and training needs in some of the textiles and garments firms were met through technicians sent for short periods by equipment suppliers or technicians hired from abroad or experienced people hired from other local firms. Another interesting example is provided by the food processing firm FP7 set up by a Ghanaian entrepreneur, a trained chemical engineer, who was able to select the equipment himself on technical merit. The suppliers sent two technicians for installation and took the production manager to Italy for a month for factory training. The foreign technicians spent only a fortnight in Ghana, and the local production and maintenance managers participated fully in the design, installation and commissioning of the plant, thus acquiring thorough familiarity with the plant and facilitating efficient operation later. The firm is now going in for a new paper packaging plant from Sweden on a turnkey basis with similar local participation. This firm's investment capabilities would appear to be one of the best in the case study sample.

Among the case study respondents, entrepreneurs who bought used equipment at start-up tended to search abroad themselves or rely on previous familiarity with the equipment. For example, the woodworking firm WW3 was started by a Ghanaian without technical knowledge on furniture-making but who had years of experience in a furniture firm in Canada. He was familiar with the names of Italian suppliers and went to Italy himself to negotiate the initial purchase of basic equipment. Similarly, the metal working firm MW7 was set up by an entrepreneur who was a plant engineer and could evaluate modern equipment based upon catalogues and visits to the suppliers.

In sum then, the investment capabilities of firms in Ghana can be rated as weak relative to those in other industrialized developing countries. The only exceptions are the MNC affiliates which can draw upon their parent companies to mount relatively complex investments. However, none have transferred their most advanced technologies to Ghana, nor have they invested in developing the investment skills of their local employees. Among local firms, investment capabilities revolve around mostly the relatively simpler technologies in use in Ghana. Most firms in the case study that utilized only local sources of information at start-up are either in wood working or metal processing sectors. Some firms in the case study sample do show substantial ability to find and transfer technologies. The needs of information, process engineering and training are met by seeking out foreign sources appropriate to the firms' requirements. However, such skill appear sparse among the firms sampled by this study. In addition, there is practically no institutional or consultancy support available to investors seeking to enter larger, relatively complex manufacturing activities.

Production Capabilities

Production capabilities of firms can be considered under two broad categories: product technologies and process technologies. Product technological capabilities include improvements in product design or the introduction of new product designs. Process technological capabilities, on the other hand, refer to plant design and layout of the production line, quality control, maintenance and repair, and industrial engineering. Industrial engineering as a distinct activity is so rare in Ghana as to not to merit separate discussion. In what follows, process capabilities and then product capabilities displayed by Ghanaian manufacturing firms are evaluated.

Process Technological Capabilities

The largest metalworking firm in the case study, MW1, started as a turnkey plant purchased from a UK supplier around 1975. The supplier designed the plant, procured the equipment and did the commissioning and initial training. However, there were various problems with the transfer of the technology and the design of the plant that the firm could not remedy. For example, one of the two furnaces was not successfully commissioned and was left inoperative. The design of the plant was inefficient, involving high in-plant transport and reheating costs; and the training was inadequate to ensure the smooth operation of the technology. Therefore, operating efficiency was always very low.

Some time later, MW1 asked some Italian consultants to improve the initial technology, again on a turnkey basis. The Italians made several changes to the original technology, including changing the dimensions of the rolling mill machinery to produce different sizes of bars and rods. Without a thorough grasp of the technology, this made the plant even more difficult to operate and further lowered its operating capacity. The Italians also provided an expensive continuous casting machine (an efficient but complex technology) and a new foundry. Neither, however, was ever brought into production and the equipment lay idle while the plant operated at 10 percent of its capacity.

By the end of 1980s, the government decided to sell part of the ownership by tender and an Indian firm bought 60 percent of the equity in 1991. The new owners imported 17 experienced engineers and steel technicians from India to take charge of all the main technological functions in the plant. They started a thorough process of refurbishing and upgrading the machinery with only modest new investments in the plant. Some of the important changes and improvements made included: bringing into operation the second furnace after making some technical modifications; improving the operation of the first furnace so that it could operate 24 hours a day, which it could not previously; putting into operation for the first time the continuous casting machine by getting certain missing items made; adjusting the rolling mill so that the modifications made by the Italian consultants could be reversed (the bearings and skid lengths were changed to prevent frequent breakdowns); and, replacing ingot production with billets and changing molds and patterns to suit the size needs of the market. An in-house workshop was critical to many of the improvements made since there was little available by way of local suppliers or technical services. Within a year under the new management, the plant was operating at more than three times its previous capacity levels and the firm is able to meet UK standards for its products.

This example clearly illustrates how the lack of process technological capabilities can cripple a plant with complex technology, and how the injection of a modest amount of such capabilities can raise productivity and efficiency dramatically. The example is also illustrative of the generally low levels of process technological capabilities in Ghanaian manufacturing firms. One manifestation of low process capabilities is evident in Table 7.6 in the virtual absence of technical adaptation of equipment purchased by firms. Except for medium-sized firms (employment of 50-99 workers), less than 15 percent of firms carried out technical adaptation and none of the microenterprises did so in the larger RPED survey sample. In the case study firms, the low capability levels are reflected in the form of poor plant layout, badly-maintained machinery and equipment, and the limited ability to troubleshoot and make repairs in the event of malfunctioning equipment. Another way to quantitatively highlight the low levels of process technological capabilities in the Ghanaian firms is to look at the amount of *technical effort* devoted to QC and maintenance. Table 7.9 shows the number of case study firms with at least one full-time employee assigned to the tasks of quality control and maintenance, respectively, as well as the range for the percentage of such employees relative to the total work force in firms in each sector.

Table 7.9
Ghana —Full-time Personnel in Quality Control and Maintenance

		Quality Control (QC)			*Maintenance*		
Sector	*No. of Firms*	*No. of Firms w/at least 1 QC employee*	*No. of QC Employees*[a]	*QC Employees as % of Employment*[b]	*No. of Firms w/at least 1 Maintenance employee*	*No. of Employees in Maintenance*[a]	*Maintenance Employees. as % of Employment*[b]
Food	7	7	39	2.18	7	111	6.19
Textiles & Garments	8	2	4	3.33	3	6	3.85
Wood	7	1	1	0.68	2	7	1.88
Metal	8	2	2	1.98	4	9	3.33

[a]Full-time personnel employed in these functions. Includes all employees, regardless of qualifications. Does not include part-time personnel or technical visits from abroad.
[b]Does not include firms without any full-time employees.

Source: RPED Case Study Data, 1992.

In interpreting these figures, it should be noted that the technological needs of production processes vary by industry. In broad terms, for the present set of activities in Ghanaian manufacturing, garment manufacture has the least demanding processes, and certain forms of food processing and metal working the most demanding. However, while all food processing firms in the case study had at least some employees specifically for QC and maintenance, the metal working sector shows little distinction from the other two, less demanding sectors. This reflects to some extent the enormous differences in the metal working sector between the technologies of different enterprises — ranging from complex steel melting and rolling to simple welding and shaping operations.

Notwithstanding these variations in technologies, it is reasonable to say that the levels of technical effort in QC and maintenance activities are low in terms of other industrializing countries, including the other two Sub-Saharan countries considered in this study. For example, the two (of eight) textile and garment firms in the case study have QC manpower equaling 3.3 percent of the total work force for each. In comparison, firms in the same sector in Sri Lanka have 4.5-9.5 percent of their work force in QC (See Lall and others 1994) Only one of the textile and garment firms in the case study, TG1, had a regular routing for maintenance and servicing. It was also the only firm with an in-house workshop with the capacity to carry out repairs and make some spares. TG1 had also introduced computer-aided design (CAD) technology for making logos on T-shirts and was the only firm to have a formal productivity monitoring system and a payment system based on worker productivity. In woodworking, only two firms (WW1 and WW3) showed evidence of reasonable mastery of process technology. Both firms have well-maintained plants and WW1 has very good QC system.

Another way to highlight the relatively low levels of process technological capabilities in Ghanaian manufacturing is to consider the food processing sector which, on the whole, shows much greater evidence of competent process capabilities relative to all the other sectors in the study. The three MNC affiliates draw heavily on their parent companies for technological inputs, with one (FP2) having a long-term technical assistance agreement with the parent company (for which it pays 2 percent of sales). This firm operates with equipment that is 40-50 years old but has good maintenance and QC facilities and regular inputs of technical assistance from the parent company. Both FP1 and FP6, the other two MNC affiliates, have started to invest in productivity and quality-raising measures with the introduction of strict industrial engineering routines, improving layout and QC facilities, and expanding maintenance operations. FP1, an affiliate of one of the world's leading food MNCs with operations in practically all industrializing countries, provides a benchmark to evaluate technical efficiency in the best local firm in Ghana in food processing. A worldwide comparison of productivity of a hundred-odd affiliates by the head office of FP1's parent firm showed that, in 1992, the *Ghanaian affiliate had the lowest productivity of all its operations worldwide* (Lall and others 1994). This provides an indication of how much further behind other local firms are likely to be in the food processing sector, which in turn seems better placed than the other sectors studied here.

Product Technological Capabilities

This section is quite brief since there is little independent product design capability in the case study firms apart from copying of imported products and designs. In garment, the markets served need little design effort. Most uniforms are suggested by customers but some school uniform designs are suggested by the firms. There is no evidence of innovation in design apart from TG1's attempt to use CAD technology to design logos for T-shirts. Similarly, the wood working industry also displays practically no independent design capabilities. Most designs, whether chosen by the firms or by the customers, come from foreign magazines and catalogues. Furthermore, the ability to interpret these designs in production is also low. The designs are sketched crudely without proper technical specifications, and then "interpreted" by the craftsmen.

Some level of design activity is intrinsic to production in the metal working industry, since many products have to be crafted to specific needs. However, this design activity is at a fairly low level, with few research or information needs, no sustained experimentation, and undemanding process specifications. Most designs are based on imported concepts, implemented without rigorous stress on tolerances and quality. Only one firm, MW7, claimed to have introduced new products of its own design but even these are essentially adaptations of products that exist elsewhere. Much of the design effort consisted of adding new features to older products to make them more reliable and stronger. Even this level of effort, however, marks this firm as one of the best in terms of product capabilities in the metal working sector.

Finally, in the food processing sector, the MNC affiliates get almost all their product technology from their parents. Local adaptations have consisted of attempts at compensating for lack of imported inputs or lowering of quality to make products more affordable. Two of the local firms in the case study, both fruit processors, have developed new products in their QC laboratories; these were the introduction of new types of fruit drinks.

Learning Mechanisms

The preceding evaluation of the investment and production capabilities of the firms provides a summary descriptive analysis of the *levels* of technological capabilities in Ghana's manufacturing sector. An equally important set of issues relate to the dynamics of such capabilities: specifically, the nature of various linkages and learning mechanisms that can allow firms to increase the levels of their technical capabilities. The discussion here follows the conceptual framework discussed in an earlier chapter by focusing separately on learning mechanisms that are internal to the firms, and private or collective mechanisms outside the firms.

Internal Sources of Learning

There are various learning mechanisms internal to the firm that can enhance its ability to learn by doing and thus enhance its technological capabilities. Here, they are discussed in terms of training within firms, efforts at research and development, and investing in stock of human capital that can increase the capacity of firms to absorb technical knowledge generated within or outside the firm.

On-the-Job Training. Training on the job can take place immediately upon hiring, as new recruits are trained for firm-specific tasks they will be performing. More formal on-the-job training that can be ongoing at different levels of capabilities within the work force of the firm. The former occurs in almost all the case study firms interviewed in Ghana and is structured similarly, although is not identical, to the apprenticeship system used pervasively in Ghana by firms of all sizes. Thus, almost all the firms train newly-hired workers for different periods of time, depending upon the nature of the tasks involved, while 10 firms in the sample (6 in wood working and 4 in metal working) use the apprenticeship system for training their work force. The apprenticeship lasts from 6 months to 2 years in the wood working firms while it is longer in the metal working sector, ranging from 2 to 5 years. The apprenticeship system is generally well suited for the transmission of fairly simple manufacturing skills to workers with minimal formal education. It is less suited to training for the skills needed for modern manufacturing where completely different types of skills than those possessed by traditional craftsmen may be required, and which typically entail a higher level of education.

Formal on-the-job training is carried out by only a few of the firms sampled in the case study. The level of investment in such human capital development is generally geared towards meeting basic production needs rather than to upgrading the stock for coping with technical change and competitiveness. In the textiles and garments sector, only two firms, TG1 and TG5, have training programs. All staff in TG1 also get occasional half-day courses by the production manager on quality control. In the food processing sector, FP1 and FP2 are the only firms providing formal training programs. FP1 has probably the best training program among all sampled firms: apart from training of new recruits, there is an annual training for all employees coordinated by an expatriate training officer; technical training is conducted on the job by expatriate trainers; and upper management is sent to FP1's training center in the parent's home country for courses in management and marketing. Only one wood working firm, WW1, undertakes specialized training program with extensive training in-house for three years as well as occasional QC training for some staff. Finally, in the metal working sector, MW1 provides significant on-the-job training but primarily to new recruits. Most other firms in this sector rely on apprenticeship systems or short training for new hires.

Table 7.10 below presents data on external training of personnel by the firms in the case study. Only 9 out of the 32 firms sent their personnel on external training of which 5 were in food processing and 3 in metal working; no firm in textiles and garments sector undertook external training for its work force in that year.

Table 7.10
Ghana — Personnel Sent on External Training in Ghana and Abroad in 1991

Sector	*No. of Firms Sending Personnel to External Training*	*No. of Personnel Sent*	*Personnel Sent as Percent of Employment*[a]
Food Processing	5	26	1.93
Textiles & Garments	0	0	—
Wood working	1	2	1.5
Metal working	3	6	4.65

[a]Does not include firms not sending any personnel for external training.
Source: RPED Case Study Data, 1992.

Research and Development. None of the firms in the case study conducts what is normally understood as formal research and development. Even the large MNC affiliates do not claim to undertake R&D. The same negligible scope of R&D in Ghanaian manufacturing is also reflected in the larger sample of firms covered in the RPED survey. As seen in Table 7.11 below, only five firms undertook R&D expenditures equaling US$10,600 in 1992, or 0.01 percent of their sales.

Table 7.11
Ghana — R&D Expenditures by Sector

Sector	*No. of Firms Doing R&D*	*Amount Spent (US$ 000's)*	*Sales (US$ 000's)*	*R&D as % of Sales*	*R&D as % of Total Industry R&D*
Food Processing	0	0.0	14,836	0.00	0.0
Textiles & Garments	0	0	26,835	0.00	0.0
Wood working	1	2	11,465	0.08	92.5
Metal working	3	6	21,740	0.00	7.5
Total	5	10.6	74,876	0.01	100.0

Source: RPED Survey Data, 1992.

Aside from formal R&D efforts, the internal learning capacities of firms may also be positively related to the presence of scientists, engineers and technicians employed by the firms. Similarly, the presence of specialized expatriate personnel in the firms' work force can also be conducive to enhancing the technical effort and internal learning within the firms. Table 7.12 summarizes the technical manpower indicators for the firms in the case study.

Table 7.12
Ghana — Technical Manpower Indicators

Sector	*No. of Scientists, Engineers and Technicians Employed*	*% of Employment*[a]	*No. of Expatriates Employed*	*% of Employment*[a]
Food Processing	180	10.04	9	0.86
Textiles & Garments	6	2.10	1	1.1
Wood working	17	1.88	2	0.60
Metal working	42	5.35	21	4.41

[a]Does not include firms not employing technically skilled workers (or expatriates).
Source: RPED Case Study Data, 1992.

As would be expected, firms in the food processing sector display the highest indices of technical manpower among all the firms in terms of both scientists, engineers and technicians employed as well as the numbers of specialized expatriates working. The textiles & garments and wood working sectors, on the other hand, show the lowest stock of technical manpower indices. The employment of technically skilled personnel in the case study firms shows very low levels in comparison to other industrializing countries in Asia and Latin America. Aside from the firms in food processing, none of the firms in the sample employ any scientists. In metal working firms, engineers represent less than 1 percent of the firms' total employment. This can be compared to 3-12 percent of the employment representing engineers in large engineering firms in South Korea, India and Malaysia. Comparably sized engineering firms in Sri Lanka have 2-4 percent of their total work force as engineers (See Lall and others 1994).

External Sources of Learning

In principle, two types of external learning mechanisms can contribute to firms' enhancement of their technological capabilities: private mechanisms, stemming from interactions with the firm's buyers and suppliers and the inter-firm spillovers of knowledge from the vertical and horizontal links among the firms; and collective mechanisms. Collective learning mechanisms, in turn, can be of two different forms, namely, the existence of an "information-rich" environment, and firm-specific "high-intensity" technological support through, for example, formal technology transfer agreements and sustained joint work with specialist technology institutions. Each of these have been discussed further under the conceptual methodology (Chapter 1). The focus now shifts to covering the manifestation and scope of these learning mechanisms in case of Ghanaian manufacturing firms.

Private Learning Mechanisms: Transactions with Buyers, Suppliers and Inter-Firm Linkages. Strong inter-firm linkages, including with buyers and suppliers, involve the exchange of skills, information and technical knowledge and can be a useful catalyst in enhancing technological capabilities of all firms involved. Such linkages are often a very effective form of technology and information diffusion, especially from large to small enterprises. However, the vertical and horizontal links among Ghanaian manufacturing firms appear to be feeble or virtually non-existent. There is little subcontracting or local procurement of manufactured inputs and spare parts. Apart from the purchase of some repair services, large firms in the formal sector have practically no relations with small firms, especially with those in the informal sector. Indeed, as shown in Table 7.13, even the small and informal sector firms have extremely low levels of procurement linkages with other local firms.

At least 70 percent of the small and micro-enterprises have 0 percent of their product components subcontracted locally, while among the larger firms about 90 percent have no local procurement of any of their product components. In cases where some local procurement does exist, it appears to be very low, rarely exceeding 50 percent of the products' components.

The data on local subcontracting across sectors show a similar picture with almost 90 percent of the firms in food processing and textiles & garments having no local subcontracting of their product components. Metal working, which is normally the most linkage-intensive industry of all manufacturing activities, shows a relatively greater level of subcontracting as does the wood working sector which relies significantly on local raw materials. But even in these sectors, close to 70 percent of the firms have no local procurement of their product components.

Table 7.13
Ghana —Indicators of Linkages by Firm Size and Sector

	Percent of Product Components Subcontracted Locally		*Percent of Firms Citing "Other Local Firms" as the Main Source of Information on Equipment for:*	
	0%	*>50%*	*Initial Capital Stock*	*Most recent major investment in plant and equipment.*
No of Employees				
<10	81	2	35	35
10-49	72	2	23	26
50-99	88	6	13	13
100+	91	0	6	0
Sector				
Food	90	3	24	16
Textiles & Garments	93	0	39	28
Wood working	68	3	16	23
Metal working	76	2	22	19

Source: RPED Case Study Data, 1992.

In contrast, there appears to be some evidence of diffusion of technological information among firms as indicated by the number of firms finding other local firms as the most important source of information in their acquisition of machinery and equipment. Both in terms of the initial acquisition of plant and equipment as well as in acquiring new machinery or tools, almost a third of all microenterprises and a fourth of the small firms cited other local firms as the major source of their information. Such flows of information are less prevalent or important among the larger firms, and non-existent or irrelevant for the largest firms who tend to rely on foreign sources of information (the larger firms constituted the case study sample and their acquisition of technology was discussed earlier in this chapter).

Two other private external mechanisms firms can utilize are foreign licenses and technical assistance agreements. Both are instruments for importing technology and can often be positively related to internal technological effort in firms. Only four firms in the case study had taken foreign licenses, two each in the food processing and metal working sectors. Of these, three firms were affiliates of foreign MNCs (FP1, FP2 and MW4) and one was a local firm (MW3). The food processing firms licensed their technology as well as brand names from their parent companies while the metal working firms only licensed some designs for doors and windows. The impact of the new technologies transferred through licensing was, thus, marginal in this sample.

Purchases of technical assistance by the sample firms were more prevalent with 10 firms in 1992 having such contracts overseas. Again, most of these firms were in food processing and metal working sectors. The expenditures on technical assistance, however, were fairly low: the two food processing MNC affiliates (FP2 and FP6) spent 1.5 to 2.0

percent of sales on technical assistance provided by their parent companies while two other firms for whom expenditure data are available, both local (WW1 and MW2), spent 0.6 and 0.06 percent of their sales. In general, therefore, very few Ghanaian firms were trying to improve their technological capabilities by importing know-how from abroad.

Collective External Mechanisms. External mechanisms that are collectively provided by the government, NGOs or donor programs can create an information-rich environment of institutional or private sources of training opportunities, and of information outlets that address specific business problems as well as foster the availability of networks of specialized consultants. Although there are a number of collective institutions existing in Ghana, their manifest success in creating an information-rich environment of direct use to the manufacturing sector appears limited.

Table 7.14 presents data on firms' reported use of key support services in the RPED survey. Clearly, linkages of manufacturing firms with technology institutions and universities are also quite tenuous. The most common interaction has been with the Ghana Standards Board (GSB). The GSB visits many of the firms on a regular basis to check the quality of their product, with the food industry having the highest incidence of contacts. However, GSB does not go beyond checking quality. It does not provide advice on how to improve quality or to prepare to meet international standards. GSB therefore does not perform the valuable function of diffusing technological information and raising quality that good standards institutions do in more industrialized economies.

Table 7.14
Ghana — Number of Firms Using Key Support Services in Panel Sample by Firm Size and Sector, 1991

	Food Research Institute	*Industrial Research Institute*	*Ghana Instrumentation Center*	*Ghana Standards Board*	*Kumasi Technical Univ.*	*Ghana Regional Appropriate Technology Industrial Services*	*Intermed. Technol. Transfer Unit*	*Total*
Firm Size								
≤10	6	6	6	7	5	7	6	43
11-50	6	3	3	17	7	5	2	43
51-100	0	1	1	6	1	1	1	11
101+	1	1	2	10	3	2	2	21
Total	13	11	12	40	16	15	11	118
Sector								
Food	4	2	2	16	2	2	3	31
Textile	3	3	4	7	4	3	2	26
Wood	3	3	3	6	5	3	3	26
Metal	3	3	3	11	5	7	3	35
Total	13	11	12	40	16	15	11	118

Source: RPED Survey Data, 1992. Sample Size is 179 firms.

The other institutions used on occasion are the Food Research Institute (FRI), the Kumasi University of Science and Technology and the Government Instrumentation Center.

FRI is used by food processing firms primarily to do tests (e.g., microbiological tests or quality tests) rather than to help with process or product technology. In general, therefore, these figures strongly suggest minimal linkages with collective institutional mechanisms and the manufacturing sector in Ghana. This may reflect deficiencies on both sides: the firms may lack the ability to identify their technical problems and formulate them into projects that can be dealt with by an institution, and the institutions may lack the skills and equipment to offer practical assistance to problems faced by firms. The outcome, in either case, is adverse for enhancement of technological capabilities in Ghanaian manufacturing.

Part III:
Conclusions and Policy Recommendations

8. Technology Policy for Africa

We began this study with the argument that improving the price structure, increasing competition via trade liberalization, and privatizing publicly-owned enterprises are *unlikely* to be sufficient for successful industrial development in Africa. Additional efforts will be required to address supply side constraints. One of the most critical is the development of technological capability in African firms. Technical skills must be raised to allow a more elastic supply response and to enhance the prospects for productivity growth.

This study has examined two areas of technological capability in African firms. The first revolves around the knowledge and skills needed to *establish* and *operate* given production systems at competitive levels of static efficiency. One observes three indicators which reflect the low aggregate static efficiency found in Sub-Saharan Africa: (i) large differentials in average technical efficiency across African countries, from Ghana to Zimbabwe; (ii) within "given" industries in each country, significant inter-firm variation in technical efficiency; and (iii) considerable efficiency differences between African plants and international "best practice" plants, even in the most efficient African firms. The second area of technological capability we examine involves the knowledge, skills and available learning sources required to *change* production systems and create new sources of comparative advantage. Again, one observes in Sub-Saharan Africa considerable variance in comparison to international best practice in the capacity of firms to "transform." The intensity with which the technology in use is changed by continuing adaptation, improvement and development varies significantly across firms from international best practice. And there appears to be low average dynamic efficiency in shifting from domestic activities to new bases of comparative advantage in export markets.

One of our principal objectives has been to analyze the sources of these inefficiencies with an eye toward developing technology-improving policy instruments to spur TFP growth. This chapter uses the results of this analysis to develop a framework for understanding the public policy actions necessary to increase the acquisition of technological capability and enhance manufacturing productivity. In view of the fact that price and technology-improving policies generally reinforce each other, the analysis that follows assumes countries have adopted the typical package of structural reforms — from fiscal reforms to trade and financial market liberalization — and, as a consequence of the new structure of prices and competitive pressures, firms are actively interested in improving productivity.

A Framework for Formulating Public Policy

We have shown in this study that Africa is not a homogeneous region in terms of industrial development. Considerable inter-country heterogeneity exists in the amount and sophistication of manufacturing activity and in endowments of technological capability. This heterogeneity is evident in the significant cross-country differentials in average enterprise TFP exhibited in Chapter 3, as well as in the enterprise data presented in the country case studies in Part II. In recognition of these differences, public policy in support of the acquisition of technological capability should be based on an empirical diagnosis of the sources of inefficiency in each case.

To guide such an investigation, one can utilize a rough decomposition of the determinants of observed inefficiency. [77] The summary measure of technical inefficiency in Chapter 3 can be decomposed into four component determinants corresponding to categories of potential policy concern: (i) those that affect efficiency indirectly by altering the functioning of the national economy; (ii) those that directly affect the efficiency of the industry as a whole; (iii) those that influence the technical capability and efficiency of the individual enterprise; and (iv) those whose main impact is on the task-level efficiency of individual workers.

At the national level, the incentive structure exerts an important influence on the desire (and necessity) of an enterprise to strive for high efficiency, particularly policies affecting international trade, finance, labor and product prices, as we have already noted. The efficiency of individual firms will be influenced by characteristics of specific industries, such as the level of concentration in the sector. Industrial concentration and the extent of vertical integration, for example, may affect cost structures and diffusion of technology among firms. At the firm level, a number of technical capabilities will affect efficiency, as we have described in the country case studies. For example, organization and layout of plants, quality control and industrial engineering all are important to achieving high efficiency with any given set of machines in a firm. Task-level efficiency will depend upon workers' capabilities and motivation, which are affected by the internal incentive structure of the firm, the quality and intensity of supervision, internal and external training programs, and general organizational characteristics, such as whether workers feel well-treated.

It goes without saying that such a decomposition of the sources of inefficiency is basically a heuristic device in that it indicates only proximate, not the ultimate, sources of manufacturing efficiency. Thus, with respect to task-level productivity, the immediate locus of low worker efficiency may be inadequate training by the enterprise. However, the firm's own cost of training will be influenced by the effectiveness of the national education system, as well as the availability of industry-specific training courses. Additionally, the adverse incentive effect of excessive trade protection may manifest itself at the industry and firm levels in the form of inordinate product differentiation and inadequate technical know-how.

In spite of the complexity of the causal links, our decomposition is useful for identifying the different levels of policy concern. In helping to pinpoint where the sources of inefficiency reside, it also provides indications of some potential policy instruments to remedy these deficiencies in the short and in the longer run. As we will try to make clear, it is our contention that the focus of technology policy should be on the firm and on the private and collective learning mechanisms that help it accumulate technological capability over

[77] For an application of this decomposition to the Philippines, see Howard Pack, "Productivity and Technical Choice: Applications to the Textile Industry." *Journal of Development Economics*, 16:1984.

time. The remainder of the policy discussion of Part III is organized around the different levels of the decomposition of the sources of inefficiency.

National-level Policies

Nationwide policies in the form of macroeconomic policies, financial system development, infrastructure, and national education attainment have an important impact on the operational efficiency of *all* firms. Such systemic effects were shown to be highly significant in the analysis of Chapter 3 (country dummy variables indicated that Zimbabwe's firms, on average, had about 80 percent higher productivity than firms in Ghana and about 40 percent higher than firms in Kenya because of these systemic effects).

In formulating appropriate national-level policies to support the development of technological capability and productivity improvement, the length of gestation period of impact should be considered. In the near term (perhaps two to three years), efforts should be devoted to raising the efficiency of existing firms by alleviating some of the key constraints on capacity utilization. The regressions in Chapter 3 indicated that capacity utilization has a significant influence on productivity in all three countries. Removal of regulations which affect such things as access to foreign exchange, timely access to raw materials and spare parts, can have an immediate effect when plants are capacity-constrained because of such factors. Improved infrastructure services, like more reliable electricity generation, can also have a substantial impact.

National economic policies with a longer term objective would address key issues having a longer gestation period, like education and infant industry protection. It is also clear that these policies should be conditioned by some rough notion of the industrial sector's long-run comparative advantage.

Policies which affect changes in the stock of skilled manpower should be a priority long-run concern for two reasons. First, dynamic comparative advantage of particular industries is very sensitive to small changes in the scarcest factors of production. Thus, the domestic resource costs currently calculated, given existing resources and prices, may differ widely from those that would result from a relatively small addition to the pool of industry-specific skilled manpower (Pack 1993). Pack cites the example of cotton textiles. It satisfies many of the criteria for successful industrialization and should emerge in Africa as a low domestic resource cost activity. Assuming the correct choice of technology, the capital-labor ratio is low, it is a process-based industry and the linkages with other manufacturing sectors are limited; so cotton textiles can grow unconstrained by the inefficiency of these other sectors. The emergence of a competitively viable cotton textile and garments industry can be severely constrained, however, by the absence of 50 or 60 key technicians.

The second reason to make the stock of human capital a priority issue is that the general level of educational attainment constrains market responses to skill shortages. In more industrialized countries with higher overall educational attainment and many trained workers, a relatively small increase in wages of textile technicians would provide the requisite incentive for emerging supplies. Small amounts of additional training, given the greater general education base, is all that is necessary. With few individuals with the required educational background, a similar response is unlikely in Africa. Thus, fully informed, market-determined supply responses face particular difficulties in Africa.

The sensitivity of comparative advantage to small changes in scarce resources and the need to alleviate constraints to market-determined responses to human capital shortages may be arguments in favor of relatively narrow manpower development programs in Africa, geared to sectors which are likely to improve their domestic resource costs relative to others. Such programs might include efforts to improve general education aimed at business, engineering and technical subjects, industry-specific training, and liberalization of regulations or restrictions on hiring expert expatriates. A strategy for increasing scarce human capital will work best if undertaken in an environment with substantial technology transfer in the form of direct foreign investment and significant interactions with foreign buyers and suppliers, all of which will assist in focusing national human capital development on the job.

A second national policy area with a long-term objective is trade policy. Most of the successful 20th century developers have had some form of infant industry protection. There is no reason why Africa should not benefit from such policies to promote learning, if properly administered. Relatively low rates of effective protection could be granted to particular industries to enhance the incentives for technological capability building. However, there are at least three questions which need to be addressed before a program of infant industry protection is launched. What sectors will receive effective protection? How will the explicit investments in acquiring and accumulating knowledge take place? How will this trade policy be administered, monitored and enforced?

The answer to the first question involves some estimation of the characteristics of industries whose long-run domestic resource costs will trend downward toward internationally competitive levels. It has been argued that, given Sub-Saharan Africa's human resource endowments, industrial development experience and current industrial structure and efficiency, the following characteristics might provide the basis for achieving competitive long-run domestic resource costs (Pack 1993):

- Considering Africa's literacy rates and educational attainment levels, industries would be unskilled labor-intensive;
- Given that domestic suppliers in most countries are often highly inefficient, relatively self-contained production with few strategic linkages to other industries would be critical; and
- Considering the requirement for experienced, highly-skilled managers and technicians, industries with products exhibiting rapidly changing characteristics or rapid technical change in production techniques would not fare well.

Based on these characteristics, relatively low rates of infant industry protection could be extended to labor-intensive sectors whose production is based on continuous processes, like textiles and garments, food processing and woodworking. Non-process industries, such as production of complex machinery, which requires high human capital and implies neither a current nor near-future comparative advantage, would receive no protection.

Having reached some decision about the set of industry characteristics which might provide predictions about long-run comparative advantage, next one has to specify how these industries, under protection, will raise their technological capabilities to internationally competitive levels. The development of technical capability is not an *automatic* by-product of infant industry protection.[78] Firms have to make specific investments to learn. And, as we discuss in more detail below, in an environment like Sub-Saharan Africa, where learning sources are weak or not in evidence, there are good reasons to expect under-investment in creating the necessary technological capabilities to move down the learning curve in sufficient time. Hence, together with a policy of trade protection, there would have to be a concerted firm-level effort to address the learning problem (more on this in the section on firm-level policies).

Lastly, there is the question of how to administer, monitor and enforce an infant industry trade policy in Sub-Saharan Africa. Infant industry protection should be both performance-based and time-based. If firms do not show improvement in their cost structures and product quality over time, there should be a credible threat that protection can be removed. In addition, protection should not be forever. A specific timetable should be worked out for the time when firms will be strong enough to compete on their own and protection will stop. Unfortunately, the political environment in most African countries, particularly the ability to withstand rent-seeking activities — plus the inexperience and lack of depth of competence of the public bureaucracy — does not bode well for effective monitoring and enforcement of infant industry trade policy, even though some protection might be helpful in promoting learning. An additional problem that many African countries face in inplementing an effective infant industry trade policy is enforcement at the border. In most cases, borders are completely porous and impossible to monitor. Any increase in protection simply encourages more smuggling.

It is this last question of how to effectively administer, monitor and enforce infant industry protection which probably makes it, for all practical purposes, unfeasible in Sub-Saharan Africa. But this does not say that massive trade liberalization should proceed everywhere. It is important that consideration be given to its timing and to its coordination with other aspects of reform, such as fiscal reform and financial reform. Greater emphasis should also be placed on ameliorating those aspects of the business environment which raise costs for producers as liberalization takes place.

[78] Nor is it an automatic by-product of trade liberalization.

Industry-level Policies

The principal objectives of industrywide policies in Africa should be to reduce the interfirm variance in efficiency observed in given industries, and to raise the average productivity of the best local firms closer to international best practice. The analysis of the efficiency frontiers in Chapter 3 and the country case studies indicated that there are significant productivity differences between enterprises in given industries, particularly interscale differences. An important potential source of aggregate productivity growth could be realized by reducing these differences by increasing the productivity of less efficient firms towards that of domestic best practice. Further productivity gains could be garnered by raising the efficiency of the best local firms towards internationally realized productivity levels.

The conventional wisdom has been that observed efficiency differentials would diminish automatically with the advent of trade policy reform and reforms in so-called competitive policies. To some extent, this conventional wisdom has been correct. The heightened competitive pressure induced by policy reforms in most countries *is* causing firms to reduce sloth and slack and move towards best practice. There are, however, some problems which might be lessened by proactive, industry-level policies.

First, a shift to a more competitive environment with better price structures may not be enough to significantly close the efficiency gap, if technology improvement requires conscious, coordinated effort by managers. Greater competitive pressure will only influence productivity where capable managers are in place with the financial wherewithal to respond purposively to the new incentives. Given the skewed distribution of technical capability indicated by the country studies in Part II, policy reform by itself might lead to some firms moving toward best practice while overall interfirm variance in productivity increases.

Together with policy reform, industry-specific training and technical assistance programs might help to overcome such problems. Most of such measures would be aimed at the firm-level and these will be discussed in the next section. Some measures, however, must be organized at the industry-level. For example, firms will tend to underinvest in general types of training because worker mobility may not allow them to reap the full benefits from these investments. For this reason, basic, industry-specific types of training are best organized on an industrywide basis, where firms are induced to cooperate in the effort via membership in industry associations or by government. [79] In such cases, all firms would pay some contribution to basic industry-specific training based on, say, a profits tax or some other scheme. To be effective, it is best that such training schemes be run with a good deal of firm involvement. There are currently vocational training programs in many African countries, financed by "training levies," which are operated by government at much too great a distance from real businesses. Genuine, industry-run programs or those with heavy

[79] Strong industry associations can play a critical role in this context. For example, Levy and others (1994) document the greater importance to firms of training courses offered by industry associations relative to those offered by the government in some East Asian and Latin American countries.

business-government cooperation tend to be most successful, as the experience in East Asia indicates.

A second area where industry-wide policy may be called for arises where the source of inefficiency results from insufficient product specialization within firms. In many African industries, firms produce a diverse array of products, foregoing the benefits of specialization. In some sectors, like textiles, evidence indicates that the absence of horizontal specialization decreased TFP by 30 percent in integrated textile mills, which engaged in the assorted activities of spinning, weaving and dying (Pack 1987). The problem is how to achieve greater specialization if market forces, via liberalization, do not induce it spontaneously. The mechanisms that have most often been employed to obtain benefits from greater specialization are industry-wide cooperative agreements. Strengthening industry associations may again be useful in this context.

Firm-level Policies

Firms are the most important actors in accumulating technological capability because they manage learning from developing, establishing and operating specific production systems. In recognition of this fact, it has been argued that science and technology policy is often misplaced in concentrating on other institutions (Bell and Pavitt 1992). The central objectives of firm-level technology policy should be to encourage and support this learning process in existing firms and to enhance incentives for innovation and imitation.

Historical experience, gained from detailed firm-level studies around the world, directs attention to several major characteristics of the technological learning process which should be considered in formulating firm-level technology policy:

- A large part of technology, both new production processes and products, involves uncodified knowledge: rules of thumb that are acquired only with experience and only via sustained interaction with the people and institutions which embody this know-how.
- Sustained interaction between transmitters and recipients of technical knowledge is also important because it reduces uncertainty and cost in acquiring know-how. The presence of an individual with actual production experience in using the technology reduces the uncertainty and cost of acquisition below that which would be in evidence if the recipient only had a blueprint to work with.
- Because of the complexity of technology and its many uncodified elements, learning-by-doing, trial and error and step-by-step incremental learning are all important for technology transfer. Accordingly, proactive, time-consuming efforts must be made by firms to transfer new process and product technologies and these investments can be costly.
- Successful absorption of a new technology is only the first step. After the initial learning is mastered, it is critically important for firms to develop the ability to adapt and modify

practices as circumstances change. Problems arise frequently from local changes in inputs, products and processing requirements. Adaptability in these areas is especially important as firms enter world markets, where, even in relatively standard products such as textiles, frequent changes are necessary in inputs and designs.

It is these major features of technology accumulation which give individuals such a decisive role in the transmission and diffusion of technology. Both within countries and transnationally, virtually all studies of technology transfer find that the diffusion of technology results, in the main, from the movements or interactions of individuals from firm to firm and from country to country (Pack 1993). There appears to be *no* evidence that the transfer of technological know-how can be achieved effectively by other modes independently, such as via technology licenses or via blueprints sent over the Internet unaccompanied by sustained individual interaction.

Learning Mechanisms

The channels through which individuals and institutions diffuse technology to firms and workers can be classified according to the schema in Table 8.1. These mechanisms were delineated in the conceptual framework in Chapter 2 and discussed in each of the country case studies.

Table 8.1
Learning Mechanisms in Technology Transfer

- Private Learning Mechanisms
  - Internal
    - In-house training.
    - R & D.
    - Hiring expatriates.
  - External
    - Foreign buyers and suppliers.
    - Interactions with other firms (e.g., subcontracting), industry networks, or mobility of workers.
    - Courses.
    - Hiring local or foreign consultants.
- Collective Learning Mechanisms: Technical Support Services (NGOs, Government, Business Associations, Donors)
  - Broad-based
    - Cost sharing technical assistance.
    - Build up local TA services.
    - Training courses (companies or intermediaries).
    - Information services.
  - High-intensity
    - Direct technical support to specific firms.
    - Technical license agreements.

Source: Adapted from Levy B., with A. Berry, M. Itoh, L. Kim, J. Nugent, and S. Urata, 1994. *Technical and Marketing Support Systems for Successful Small and Medium Size Enterprises in Four Countries.* Washington, DC: World Bank Policy Research Working Papers Series, No. 1400.

Private Mechanisms

The leading source of technical learning in firms in all countries comes via private channels — from determined internal technical efforts of firms themselves, from business interactions with buyers and suppliers, from interactions with other firms in the same industry, from hiring consultants and other technical experts, and so on. When firms are unable to meet their technological needs internally, there will be a demand for collective technical support services of government, NGOs and donor agencies to fill the gap. Hence, external private and collective mechanisms of technical support can be viewed as partial substitutes. Of course, they are also partly complementary in that collective technical support services of governments, NGOs and donor agencies can work to enhance the effectiveness of existing private learning mechanisms.

Internal Sources of Learning: In-house technical effort is a crucial source of learning. Most small and medium manufacturing exporters, questioned in a recent survey covering Asia and Latin America, indicated that the combined effort of the entrepreneur and workers played the strongest role in the firm's technological development (see Levy and others 1994). Learning-by-doing, on-the-job training and internal tinkering, adaptation and modification are cited as the most important sources of technological capability and productivity gains over the lifetime of the firm. As we saw in the country case studies, such technical efforts are also occurring in African firms. Firms in Zimbabwe, Kenya and Ghana are engaged in training workers, research and development activity, and development and use of technical documentation and technical offices.

Where African firms appear to differ from their Asian and Latin American counterparts is in the overall incidence and quality of internal technical efforts. In-house worker training is a good example. The pattern and determinants of enterprise training in Africa, across firms, sectors and types of workers, looks rather similar to the pattern and determinants found in other countries: large firms train more than small firms; foreign-owned firms train more than domestic firms; exporters train more than non-exporters; managerial and skilled workers receive more training than unskilled workers; and so on. Where African firms differ most is in the overall incidence of *formal* enterprise training. Only a very few large firms, mostly multinationals, have any kind of formal, in-house training courses, unlike firms in other developing countries, such as Colombia, Mexico and Indonesia (see Table 4.14 in Chapter 4). The same is often true of the other elements of internal technical effort, like organized research and development activities to design or adapt new products and processes, and technical documentation to facilitate in-house learning.

Some of the difference in observed incidence and quality of internal technical effort in African firms, compared to the rest of the world, is attributable to differences in average firm size and average skill ratios of the work force. As we saw with the determinants of enterprise training, for example, larger firms with higher worker skill ratios in all countries are likely to train more than smaller firms with unskilled workers. Larger firms, because of economies of scale in training and so on, can afford to engage in more training, and particularly training of a formal nature (for more detail, see Biggs, Shah and Srivastava 1995). Policy also matters, of course. In countries like Zimbabwe, which have more elaborate vocational training systems, more privately provided training alternatives and policies to promote firm training, one tends to observe higher average enterprise training because firms (and workers) take advantage of these external training sources and because the returns to enterprise training are higher and the costs lower.

A lot more of the difference in internal technical efforts of African firms, however, can be explained by the mix of products being produced and the quality of available external support services. Many studies have shown that some production activities carry with them a high rate of skill acquisition, and other routine or traditional ones are associated with a low rate (see Lucas (1993) for a review of this literature). That is, producing a mix of traditional goods which has been produced for many years engenders a much lower rate of capability development from learning-by-doing than does producing a more modern mix of (tradable) goods. These potential learning gains can be reaped via import substitution activities or, as it appears from empirical evidence in East Asia, much more from exporting activities. The fact that many African countries have had policy regimes which have caused economic activity to stagnate, and/or created an anti-export bias, has inhibited firms from moving up the "quality ladder" in terms of product mix. The result has been much lower rates of internal technical learning-by-doing as well as much lower quality in the internal learning activities that do take place. Only Zimbabwe, during the import-substitution days of the UDI blockade, shows any visible signs of having substantially increased skill acquisition by way of learning-by-doing (see the Zimbabwe country study in Chapter 7).

The internal technical efforts of the firm will not amount to much if the environment within which the firm operates is not supporting these efforts with new inflows of know-how, new market connections and access to individuals with technical expertise. The availability and quality of business support services are crucial elements in the internal learning process. As discussed below, the fact that these external support services, both private and collective, have been weak and missing in some cases has limited significantly the effectiveness of enterprise internal technical efforts.

External Sources of Learning: External to the firm, a host of private learning channels potentially exist on which firms can draw as they seek to build technological capability. The observed importance of individual external private mechanisms for acquiring technical capability differ across countries depending on country "endowments:" that is, on a country's existing industrial organization (e.g., the extent of vertical and horizontal interfirm linkages); on the availability of industry-specific courses, specialized consulting services and useful technical information; and on the country's links with the international marketplace. Thus, in Japan, the strong vertical links between large firms, like Toyota and Mitsubishi, and their smaller subcontractors drive a large part of the technological learning process. In Italy, Taiwan, and some parts of Korea, horizontal links between small and medium firms in industrial districts or "clusters" are very important in technology acquisition. And in other countries, like Indonesia, where a recent inflow of foreign investors and buyers is driving a nascent export boom, the crucial factors in technology accumulation are the international linkages with these foreign economic agents.

Where country "endowments" are limited (that is, where vertical and horizontal inter-firm ties are weak, where connections with foreign market agents are limited, and where the micro-environment of specialized technical information and technical services is "thin"), the obstacles to enterprise learning can be formidable. Acquiring technical capability in firms in such circumstances may require proactive strategies to strengthen existing learning sources and to substitute for modes of technology transfer which are missing. The country case studies of technology endowments in Part II indicate that this is the case with Sub-Saharan Africa.

As we saw in the cases of Zimbabwe, Kenya and Ghana, with the exception of multinational companies and a few large exporters, most Sub-Saharan African firms are technologically isolated from the rest of the world. As a consequence, connections with international private learning sources, such as foreign buyers and suppliers, are weak or non-existent. Moreover, domestic firms operate in an information-poor environment. There are a small number of firms in each modern industrial sector, which means that firms cannot rely on interfirm flows of information or employees to acquire new products and production knowledge, as in more developed countries. In addition, direct foreign investment is limited, reducing the ability to "learn-by-imitating" and the ability to "benchmark" the firm's operations against internationally competitive firms in the same business. External training opportunities and specialized consulting services are also often weak or not available locally, and information services on technical business matters are very poor. Lastly, collective support services to assist technical learning are often poorly delivered when they exist at all.

The analysis in Chapter 3 showed that where African firms had access to foreign flows of technical knowledge through technical assistance contracts, technical license agreements and foreign ownership, they were much more productive. Such private external learning mechanisms increased average firm productivity by more than 30 percent. The priority task for public policy at the firm level is first to ensure that the business environment facilitates — rather than obstructs — the development and functioning of the private-to-private flow of technical know-how at home and from abroad. Measures here span a rather wide range of issues, but might include:

- Reducing the problems and costs to firms in hiring experienced expatriate personnel. This would include things like making expatriate salaries tax free, allowing expatriates to easily repatriate salary earnings.
- Making the environment better for multinational investors in key labor-intensive industries and encouraging vertical and horizontal linkages with local companies.
- Finding ways to reduce the transaction costs of subcontracting. At current levels of manufacturing activity and levels of education and skill, the transaction costs of subcontracting are likely to be quite high for some time. However, a substantial current barrier to subcontracting in Africa is the problem of contract enforcement.

Finding inexpensive ways to enforce business contracts, by way of private or public enforcement mechanisms, could reduce the transaction costs and risks of subcontracting substantially.

Considering the evident limitations of existing private learning mechanisms in Africa today, proactive interventions at the firm level to accelerate technological accumulation must be the next priority. Evidence from other developing regions of the world indicate that there are substantial benefits to be derived from collective technological support, if it is implemented properly.

Collective Learning Mechanisms

Collective technical support programs generally take two basic forms: "broad-based" or "high-intensity." Broad-based programs work to facilitate the development of an information-rich environment from which firms can draw to upgrade their technical capabilities. High-intensity collective support, on the other hand, aims to promote technical learning by supplying technological know-how directly to firms. In practice, some countries, like Korea, provide both types of support together in a single government-directed program.

Broad-Based: Taking broad-based programs first, examples of technical support services that have been popular with Asian and Latin American firms include: provision of industry-specific courses on specialized topics; facilitating the use of technical consultants, either by providing financial assistance to firms for hiring consultants, or by providing consultants directly; making technical information available; and promoting information-sharing among firms. Much can be learned from the successes of collective support programs, in "endowment-poor" Asian and Latin American countries, like Indonesia and Colombia, where vertical and horizontal interfirm links are poor and information and technical services are relatively "thin." Proactive interventions to provide broad-based technical services have been successful in assisting small and medium exporters to overcome these limitations in these countries (Levy and others 1994). Key lessons, with respect to successful delivery of services, that emerge from such programs include the following:

- Programs should make available usable information and other services, leaving it to firms to judge their specific needs and how information and technical assistance can be adapted to these specific needs. For small firms, which are technologically primitive and "don't really know what they don't know," special measures might be needed in terms of more "hands-on" assistance. The maxim for any "hands-on" assistance must be that it is "performance-based." That is, high performing firms get the assistance.
- There is a great need for providers of broad-based technical support to be close to, and familiar with, the needs of clients. A consistent feature of successful programs in Colombia and Indonesia is that broad-based support is most effectively delivered by *decentralized* institutions, like business associations and independent NGOs. The record of *centralized* provision by government agencies is uneven and sometimes

quite poor. However, centralized institutions often provide finance for operations of decentralized providers successfully.

- The demands on institutional capability of provision of successful, broad-based support in Indonesia and Colombia is found to be relatively light compared to high-intensity support programs. However, institutional weaknesses among providers cause delivery problems in some cases.
- Technical courses emerge as the most popular form of broad-based support from the firms' point of view. For example, more than 50 percent of Indonesian small and medium exporters in the wood and rattan furniture sub-sector sent workers to technical courses run by the industry association or independent NGOs. These courses were cited by firms as extremely useful for technical development. Similarly, in Colombia, small exporters in the leather and garments industries sent large proportions of their workers to courses run by industry associations and the National Training Organization. Technical consultants, provided on a cost-sharing basis (50 percent of the cost), are cited by firms as the second most useful support service in most cases.
- Access to private learning mechanisms are uneven. Private channels appear to be mostly accessible to larger firms and firms with more educated managers. Collective support was able to substitute for a lack of access to private channels. Small firms relied more heavily on collective support.

Given these lessons from Asia and Latin America, what can be said about the objectives of collective support efforts in Africa? First, if we look back at our country case studies of Zimbabwe and Kenya, the most highly desired support services, as articulated by the firms themselves (Tables 5.21 and 6.21), seem to coincide with the types of programs popular in Asia and Latin America, namely specialized technical courses and technical assistance for productivity improvement. A first priority for broad-based collective support programs should be to deliver effective services in these areas. These services will be particularly important for small, black-owned firms. As we saw in the country case studies, entrepreneurs from small, black-owned firms attended courses external to the firm more often than other entrepreneurs. In general, private learning mechanisms appear to be the most readily accessible to larger enterprises with some foreign ownership, and to educated entrepreneurs who can take advantage of private network linkages. Hence, an exclusive reliance on private learning mechanisms might reduce the participation of smaller, black-owned firms in the technological upgrading process.

Second, given the tacit nature of technology discussed earlier plus the current low technical capability endowments in Africa today, the necessary changes in production engineering to raise productivity significantly are not likely to be successfully implanted on a one-shot, short-term or sporadic basis typical of technical consulting or short courses. Ways will have to be found to provide broad-based support on a more sustained basis in Africa. Assistance with hiring experienced expatriate technicians might be one approach to this problem.

Third, given the crucial need for decentralized delivery of such services to be close to clients and the fact that, in Africa, there are few decentralized providers with the wherewithal to successfully mount such efforts, a central objective of policy must be to build up the necessary institutional infrastructure. Key institutions, like industry associations and independent NGOs need to be strengthened to deliver broad-based technical support.[80] Centralized providers, which currently deliver some of these support services in Africa, could also be encouraged to move closer to clients to increase the effectiveness of their existing programs. Particularly in the area of training, closer partnerships with firms could enhance service delivery. However, the longer-run objective, if Asia and Latin America are to be our guides, would be to decentralize delivery of support services, and perhaps leave funding to centralized providers.

Fourth, if the successful East Asian experience tells us anything, it highlights the central importance for productivity growth of learning-by-doing. Broadly speaking, learning-by-doing includes the skill development which comes from producing particular kinds of goods, as well as the knowledge which is gained from interaction with buyers and other economic agents in marketing the product. Collective support efforts need to focus on creating and maintaining foreign market linkages in Africa to foster more learning-by-doing. For example, broad-based support programs are needed to finance trips for African producers to foreign markets. Producers might receive assistance to go to trade shows and visit buyers and suppliers. Foreign buyers might also receive support to visit African producers. The objective of such support would be to obtain new markets for African producers, so that the mix of goods produced can be upgraded over time — adding to learning — and to transfer technical knowledge through market interactions with buyers and suppliers. Technical support agencies can also perform the important function of information broker in this respect: publications, seminars and exhibitions would be useful ways to transfer technical information.

Lastly, a highly desired technical support service by the firms in our case studies was the provision of quality control testing and inspection services. The focus of managers on such services reflects the perceived need in these countries to meet higher quality standards brought on by more extreme competition under current policy reform programs. These services should be part of any broad-based collective support effort.

High-Intensity: The objective of high-intensity technical support is to meet directly the specific technical needs of firms which cannot be obtained via other types of mechanisms. Demand for this type of direct support comes from firms operating at relatively high levels of technological complexity. Examples of high-intensity support include direct

[80] We do not mean to leave the impression here that decentralized providers in Africa are weak and everywhere else they are strong. Indonesia's industry associations are by no means outstanding either. Levy and others (1994) state that "...they are not professionally staffed; ...are rarely accountable to their members; ...tend to be captured by powerful players in the industry; and are consequently viewed with suspicion by smaller firms." Overall, it has been the private channels that have been responsible for most of the technical upgrading which has occurred.

technical assistance from government technology institutions in the form of productivity improvement or joint technology development programs. Again, the lessons from high-intensity technical support programs in Indonesia and Colombia are instructive for Africa:

- The demands on institutional capability to effectively deliver high-intensity technical support are substantial. Supplying agencies must have as much or more competence on sophisticated, industry-specific technical matters as the clients they serve.
- Notwithstanding the fact that both Indonesia and Colombia have publicly provided high-intensity support programs available, few firms report benefiting from these services on any significant scale.
- A central lesson from the experience of high-intensity support efforts in Indonesia and Colombia is that, at their respective stages of development, government should not be in the business of direct delivery of technology services. Public institutions generally lack the technical capability, commitment and flexibility to provide quality support services to firms. The government's role should be to facilitate and support the emergence of private networks of technology provision.

This experience is not unlike that found in our country case studies. Ghana, Kenya and Zimbabwe all have government technology institutions of one kind or another (see Tables 5.22, 6.20 and 7.14). However, few firms report using these high-intensity services and fewer still have anything good to say about them. Effectively, the only government-related technical services which firms report using with any regularity are bureaus of standards (for quality testing) and vocational training institutions. Neither of these services receives very high marks by the survey firms using them in any of the countries.

Given the record of centralized provision of support services in Africa and the pervasive organizational weaknesses of public institutions — in terms of human capital, commitment and funding — the potential for delivering high-intensity technical support is severely limited. As in Indonesia and Colombia, the government's role should be to support private-to-private technology provision. Assistance for training and technical consultants by public agencies to support delivery of these services by non-government providers on a decentralized basis would also be beneficial.

Task-level Policies

It is often argued that manufacturing task-level efficiency is low in Africa, and that the region suffers from a labor productivity deficit. What is usually meant by this assertion is deficient cognitive and manual labor skills (Pack 1993). This view of labor productivity is much too simple. Labor productivity may be low for a host of other reasons: firms, for various reasons, may not realize economies of scale, scope or specialization; managerial ability to organize plant layouts or devise effective worker incentive programs may be low, or lower capacity machines may be used than elsewhere. Studies which have examined task-level efficiency of workers in Africa, particularly in process-oriented industries with experienced, skilled managers, do not find worker productivity lagging other parts of the world. Pack (1987), for example, finds that Kenyan workers in large multinational textile plants are as productive as workers in similar plants in the United Kingdom. Biggs and others (1994) find that machine operators in multinational garments factories in Kenya, Zimbabwe and Ghana have somewhat lower task-level efficiencies (30 to 40 percent) than their Asian rivals. However, as African workers are learning-by-doing in the nascent export industry, task-level efficiency differentials are falling. Moreover, Africa's current average nominal wages in the industry are less than half the wages paid in China's export processing zones. This means that Africa has lower unit labor costs and is thus potentially more competitive.[81]

Experienced management and systematic training in multinationals make a significant difference in worker productivity. In textiles and garments, and in many other process-oriented industries, substantial previous worker experience is not a prerequisite for success. Formal and on-the-job training in firms for relatively short periods can be quite successful in raising worker productivity to internationally competitive levels, given one starts with literate and numerate workers (Pack 1993). A priority for policy aimed at increasing worker task-level efficiency should be to support enterprise training. In the analysis in Chapter 3, worker training is found to be one of the largest contributors to enterprise productivity, both in large and small enterprises. For the sample of firms as a whole, across all three countries, a one percent increase in worker training could increase productivity by as much as 60 percent; for smaller firms, the impact would be even larger, increasing productivity by as much as 100 percent (see also Biggs, Shah and Srivastava (1995) for additional information on worker training in Africa). Firms should receive financial support (perhaps on a cost-sharing basis) for their contribution to human capital development, particularly given the fact that there is a tendency for firms to underinvest in certain types of training, because they cannot capture all the benefits. The social returns of such policies should be exceedingly high considering that learning on the job has been indicated to be the most important factor in explaining rapid economic growth in the newly industrializing countries of East Asia.

The second area that policy must address at the task level is the shortage of skilled managers and technicians. For workers to be productive, they need adequate supervision, efficient plant layouts and effective incentive schemes, as noted above. Firm training also requires skilled and experienced personnel to run courses and to be actively involved in on-the-job learning. The country case studies indicated a shortage of such skilled personnel in Africa. In the short run, one of the best ways to relieve such critical personnel bottlenecks is to facilitate the hiring of experienced expatriates. RPED surveys have shown that expatriates play a key role in many high efficiency firms in training and production supervision.

[81] Unit labor cost is nominal wage divided by labor productivity.

Appendix A: Additional Tables

Table A-1
Comparative Educational Attainment, 1970-1990
(Enrollment in Percentages of Target Population)

	Primary		*Secondary*		*Tertiary*		*Adult Illiteracy*
Country	*1970*	*1990*	*1970*	*1990*	*1970*	*1990*	*Rate (1990)*
Ghana	64	75	14	39	2	2	40
Kenya	58	94	9	23	1	2	31
Zimbabwe	74	117	7	50	1	5	33
SSA	46	68	6	17	1	2	50
Bolivia	76	82	24	34	17	23	23
Colombia	108	110	25	52	10	14	13
Peru	107	126	31	70	19	36	15
Latin America	95	107	28	49	15	16	16
Indonesia	80	117	16	45	n/a	n/a	23
Philippines	108	111	46	73	3	27	10
Sri Lanka	99	107	47	74	3	4	12
East Asia	88	127	24	49	4	5	24

Source: World Bank, 1993. *World Development Report*, Table 29, p. 294-5. New York: Oxford University Press.

Table A-2
Tertiary Students in Technical Fields in Selected African Countries
(in Numbers and Percentages of Total Population)

		General Science[a]		Natural Science, Mathematics & Engineering		Engineering Only	
Country	*Year*	*No.*	*%*	*No.*	*%*	*No.*	*%*
Ghana	1987	3,516	0.02	1,886	0.01	722	0.005
Kenya	1987	12,588	0.05	5,470	0.02	3,438	0.01
Zimbabwe	1987	1,723	0.02	888	0.01	389	0.005
Côte d'Ivoire	1987	6,344	0.05	2,574	0.02	365	0.003
Nigeria	1987	45,018	0.04	23,524	0.02	8,068	0.008
Cameroon	1980	3,127	0.03	1,983	0.02	373	0.005
South Korea	1988	609,650	1.45	320,666	0.76	227,640	0.543

[a]Includes natural science; mathematics and computer science; medicine; engineering; architecture; trade and crafts; transport and communications; agriculture, forestry and fishing.

Source: UNESCO (1990), *Statistical Yearbook*, Paris: United Nations.

Table A-3
Pupils Enrolled in Vocational Education in Selected African Countries

Country	*1975*	*Latest year*	*Latest year as % of population*
Ghana	18,819	14,915	0.10
Kenya	5,468	8,880	0.04
Zimbabwe	1,312	11,104	0.12
Côte d'Ivoire	15,758	25,328	0.24
Nigeria	27,843	87,846	0.09
Cameroon	36,262	93,651	0.88
South Korea	436,538	723,193	1.72

Source: UNESCO (1990), Statistical Yearbook, Paris: United Nations.

Table A-4
Research Publications in Selected Sub-Saharan African Countries, 1981-86

Country	*Total 1981-86*	*Mean 1981-86*	*Percent of Total*	*Cumulative Percent*
Nigeria	4,529	755	47	47
Kenya	1,454	242	15	62
Zimbabwe	407	68	4	66
Tanzania	393	65	4	70
Ivory Coast	290	48	3	73
Zambia	172	29	2	75
Other	2,400	400	25	100

Source: Zymelman, M., 1990. "Science, Education, and Development in Sub-Saharan Africa." Technical Paper No.124, Africa Technical Department Series, Washington, DC: The World Bank, Table I-4.

Table A-5
Distribution of Research Publications by Field, Selected Sub-Saharan African Countries, Latin America and the World
(Percent)

Field	*Nigeria*	*Kenya*	*Zimbabwe*	*Tanzania*	*Côte d'Ivoire*	*Zambia*	*Mean SSA*	*Latin America*	*World*	*AI SSA*[a]	*AI Zimbabwe*[a]
Clinical Medicine	38	61	32	47	30	61	43	29	33	1.30	0.97
Biomedical Research	12	11	7	3	8	2	10	16	16	0.62	0.44
Biology	29	1	49	39	41	20	29	13	11	2.64	4.45
Chemistry	8	1	2	3	11	2	6	13	16	0.37	0.12
Physics	3	1	1	2	4	3	2	17	10	0.20	0.10
Earth and Space	5	2	3	3	4	8	4	5	5	0.80	0.60
Eng. & Tech.	5	1	3	3	1	2	3	4	7	0.43	0.43
Mathematics	2	1	3	1	0	1	2	2	3	0.67	1.00

[a]The activity index (AI) is obtained by dividing the share of the corresponding country or region by the share of the world.

Source: Zymelman M., 1990. "Science, Education, and Development in Sub-Saharan Africa." Technical Paper No.124, Africa Technical Department Series, Washington, DC: The World Bank, Tables I-3 and I-6.

Table A-6: Patents Granted Selected Sub-Saharan Africa Countries
(Circa Historic Period 1960-82)

Country	*Historic Period*	*Patents Granted to Residents*	*Patents Granted to Non-Residents*	*Total Patents Granted*	*Average Yearly Count*
Ghana	1963-82	0	1,155	1,155	57.7
Kenya	1965-82	6	1,901	1,907	105.9
Nigeria	1964-82	24	4,765	4,789	252.0
Tanzania	1955-82	0	1,678	1,678	59.9
Uganda	1963-82	1	1,038	1,039	51.9
Zambia	1966-82	24	2,730	2,754	162.0
Zimbabwe	1958-82	368	9,985	10,353	414.1

Source: World Intellectual Property Organization, 1983. *100 Years Protection of Industrial Property Statistics, 1883-1982.* Geneva.

Table A-7
Comparison of Patents Granted in 1985, Selected Countries

Country	*Residents*	*Total Patents*	*Proportion Granted to Residents*	*Population (Millions)*	*Total Patents per Million*	*Resident Patents per Million*
Ghana	0	1	0	12.720	0	0
Kenya	0	98	0	20.330	4.82	0
Zimbabwe	2	213	0.01	8.380	25.42	0.24
Bolivia	3	62	4.80	6.430	9.64	0.47
Peru	29	155	18.70	19.420	7.98	1.49
Philippines	22	1281	1.70	54.670	23.43	0.40
Sri Lanka	18	112	16.10	15.840	7.07	1.14

Source: World Intellectual Property Organization, 1986. *Industrial Property Statistics 1985.* Geneva (Patents) UNESCO, 1990. *Statistical Yearbook.* Paris: United Nations. Table 1.1 (Population).

Table A-8
Stock of Scientists and Engineers in Kenya and Selected Countries
(Latest Data Available)

Country	*Scientists and Engineers*	*Population ('000s)*	*Scientists and Engineers (Per Capita)*
Kenya	16,241	16,670	0.97
Nigeria	22,050	80,560	0.27
Bolivia	64,300	7,612	8.45
Peru	291,812	17,300	16.87
Philippines	1,770,762	48,320	36.65
Sri Lanka	21,533	15,840	1.36

Note: Data for Kenya is from the following years: 1982 for scientists and engineers; 1980 for population. For the other countries it is as follows: Nigeria, 1982 for both; Bolivia, 1992 and 1991 respectively; Peru, 1981 and 1980; Philippines, 1980 for both; Sri Lanka, 1985 for both.

Source: UNESCO, 1993. Statistical Yearbook. Paris: United Nations. Tables 1.1 and 5.3.

Table A-9
Zimbabwe: Technology Case Study Survey Firms, 1993

Firm	*Site*	*Empl.*	*Sales (US$)*	*Production since*	*Lic./ TA*	*Ownership Structure*	*Principal Products*
Food Processing							
FP1351	B	10	1,200,000	1990		100% LNA,A	Baked goods
FP1731	H	19	1,580,000	1985		100% LNA,E	Nyangami, crushed garlic
FP551	H	275	360,000	1980		100% LA	Spices, herbs
FP211	H	8	420,000	1989		100% LNA,E	Meat products
FP11	H	96	4,000,000	1968		51% For. 49% State	Baked goods
FP591	H	202	72,500,000	1960	1 L	100% For.	Infant foods, cereals
FP1661	B	294	18,000,000	1945		100% LNA,E	Confectioneries
FP1951	H	422	106,000,000	1974	1 L 1 TA	70% State 30% For.	Alcoholic beverages
FP1401	B	520	69,600,000	1949	1 L	60% PrvZ 40% For	Non-alcoholic beverages
FP241	H	340	n/a	1955	1 L	60% State 40% LNA,E	Confectioneries
FP361	H	1383	106,500,000	1940	1 L 1 TA	92% State 8% For.E	Snacks, canned foods
FP1221	H	2,766	51,400,000	1952	1 TA	100% State	Dairy products
FP71	H	943	117,020,000	1957		100% PrvZ	Meat packers
Textiles and Garments							
TG161	H	4	110,630	1984		100% LA	Jerseys, school uniforms
TG751	B	8	60,000	1982		100% LNA,A	Kitchen aprons, hats
TG461	H	18	1,200,000	1977		100% LA	School uniforms, ladies dresses
TG1121	B	48	7,530,000	1950		100% LNA,E	Mutton cloth, engine cleaning waste
TG1681	H	46	127,300	1981		100% LNA,E	Men & ladies underwear
TG1701	H	62	988,000	1991		100% LA	Overalls, bedsheets
TG1581	B	149	2,700,000	1965		100% LNA,E	Ladies & children's outerwear
TG681	H	195	9,000,000	1962	1 L	75% PrvZ 25% For.	Garments, dresses
TG51	H	456		1946		5% LNA,E 95% For.	Trousers, shirts
TG271	H	1634	123,000,000	1959	1 L 1 TA	100% LNA,E	Ladies & men's wear

Table A-9
Zimbabwe: Technology Case Study Survey Firms, 1993
(continued)

Firm	*Site*	*Empl.*	*Sales (US$)*	*Production since*	*Lic./ TA*	*Ownership Structure*	*Principal Products*
				Wood working			
WW41	H	3	55,000	1981		100% LA	Wardrobes, desks
WW131	H	14	1,230,000	1992		100% LNA,E	Snooker tables, pool tables
WW1471	B	53	2,700,000	1988		100% LNA,E	Bedroom suites, wardrobes
WW1771	H	87	3,200,000	1989		100% LA	Dining room suites
WW1191	B	135	4,400,000	1939		100% PrvZ	Household & office furniture
WW331	H	13	5,500,000	1967		100% LNA,E	Furniture
WW231	H	259	53,000,000	1991		100% PrvZ	Boxes, crates, drums
WW1861	H	184	12,290,988	1959		100% LNA,E	Dining room, bedroom suites
WW471	H	140	8,600,000	1973		100% LNA,E	Lounge suites, quality L-Medium
WW1921	H	246	12,400,000	1981		100% PrvZ	Lounge, bedroom suites
				Metal working			
MW521	H	18	398	1991		100% PrvZ	Vehicle parts
MW1361	B	44	549	1978		100% LNA,E	Custom sheet metal work
MW1751	H	75	10,122	1946		100% PrvZ	Parts
MW1141	B	92	268	1958		100% LNA,E	Metal products and castings
MW1641	H	79	1,341	1954	1 L	100% LNA,E	Custom fabricated metal products
MW581	H	123	1,159	1960		98% State 2% For.	Stainless steel product fabrication; large scale
MW491	H	1001	32,786	1957	1 L 1 TA	30% State 70% LNA,E	Metal cans and packaging
MW411	H	447	6,856	1951		100% PrvZ	Kitchen utensils, electric appliances

Note: H = Harare; B= Bulawayo; LA=local African; LNA=local non-African; LNA,A = Asian-Zimbabwean LNA,E = European-Zimbabwean PrvZ = Private Zimbabwean equity.
Source: RPED Case Study Data, 1993.

Table A-10
Kenya Technology Case Study Firms, 1993

Firm	*Site*	*Empl. 1993*	*Sales 1993*	*Years in Prod. in 1993*	*Products*
Food Processing					
FP10	N	129	319,000,000	31	Spirits
FP14	N	20	2,100,000	10	Snacks, cereals
FP20	N	8	1,150,000	2	Confectionery
FP28	M	60	45,000,000	10	Bakery
FP31	M	7	6,000,000	13	Coffee roaster, packer
FP32	M	31	12,000,000	12	Non-alcoholic beverages
FP38	N	136	160,000,000	24	Chewing gum
FP39	N	155	165,000,000	28	Fish filets
FP7	N	15	7,500,000	10	Bakery
Metal working					
MW11	M	5	150,000	19	Construction machinery manufacture
MW12	N	4	5,000,000	5	Locks
MW13	N	45	16,000,000	19	Car seats frames, jacks
MW16	N	186	158,000,000	23	Wire, steel wool
MW19	N	54	24,000,000	25	Spare parts
MW22	N	182	18,000,000	22	Locks, agricultural implements
MW23	M	5	120,000	2	Gates, doors, welding
MW26	M	650	400,100,000	64	Kitchenware, metal stamping and forming
MW30	M	26	18,000,000	12	Nails, wire
MW35	N	50	14,400,000	25	Stoves, barrows, kitchenware
MW40	N	6	781,000	15	Doors, windows, gates
MW6	N	23	12,000,000	16	Ginning machinery parts
Textiles and Garments					
TG1	N	27	2,360,000	11	Blazers
TG15	N	619	87,000,000	28	Textiles
TG24	M	295	22,000,000	4	Blankets
TG25	M	8	2,070,000	20	Uniforms
TG33	N	675	81,500,000	18	Sweaters, yarn, socks
TG9	N	6	338,000	1	Suits
Wood working					
WW17	N	140	27,000,000	16	Lumber
WW18	N	80	15,000,000	24	Lumber
WW21	N	180	37,000,000	18	Furniture
WW27	M	36	5,850,000	16	Furniture
WW29	M	14	9,000,000	18	Lumber, prefab construction units
WW3	N	22	2,400,000	16	Prefab houses sofa sets
WW36	N	22	2,904,000	11	Furniture. desks
WW5	N	5	2,200,000	59	Sofa sets

Note: N = Nairobi; M = Mombasa.
Source: RPED Case Study Data, 1993.

Table A-11
Ghana, Case Study Firms, 1992

Firm	*Site*	*Empl. 1991*	*Sales 1991 (US$ '000)*	*Age in production in 1992*	*Ownership structure*	*Principal products*
Food Processing						
FP1	A	650	82,918.7	31	55% State 45% For.	Evaporated milk, cocoa beverage, infant cereals
FP2	A	246	2,990.5	23	100% For.	cocoa beverage, drinking chocolate, toffees
FP3	A	228	644.3	31	100% State	Fruit juice, processed foods
FP4	A	216	830.4	36	100% LNA	Biscuits, cookies
FP5	A	200	8,155.9	3	100% LA	Flour
FP6	A	172	7,612.2	32	60% For. 40% LA	Dairy products
FP7	A	80	543.7	8	100% LA	Fruit juice and drinks
Textiles and Garments						
TG1	A	90	194.7	18	100% LNA	Uniforms (95%), printing T-shirts
TG2	A	73	163.1	8	100% LNA	Synthetic leather (90%) and derivatives (tarpaulin)
TG3	K	42	66.6	18	100% LA	Uniforms
TG4	A	30	93.7	16	100% LNA	Nets (50%), polyester fabrics
TG5	A	24	49.9	22	55% LNA 45% LA	Knitwear (mainly T-shirts)
TG6	A	15	20.1	24	100% LA	Uniforms
TG7	K	13	n.r.	17	100% LA	Traditional garments
TG8	A	0	0	1968-87	100% LA	Shirts, trousers, knitwear
Wood working						
WW1	A	267	1,359.3	14	60% LA 40% For.	Wood furniture
WW2	A	225	489.4	65	100% LA	Lumber (80%) wood furniture
WW3	A	147	407.8	10	100% LA	Wood furniture
WW4	A	135	40.8	41	100% LA	Wood furniture
WW5	K	65	81.6	16	50% LNA 50% LA	Wood furniture
WW6	K	41	21.7	14	100% LA	Wood furniture
WW7	K	16	8.4	6	100% LA	Wood furniture
WW8	A	10	4.9	7	100% LA	Cane furniture

Table A-11
Ghana, Case Study Firms, 1992
(continued)

Firm	*Site*	*Emply 1991*	*Sales 1991 (US$ '000)*	*Age in production in 1992*	*Ownership structure*	*Principal products*
Metal working						
MW1	T	430	5,200.6	27	40% State 60% For.	Structural steel rods
MW2	A	150	2,718.6	5	100% LA	Pots and pans
MW3	A	71	1,141.8	21	100% LA	aluminum doors, windows, ceilings, partitions
MW4	A	30	40.8	35	40% For. 60% LA	aluminum doors, windows, ceilings, partitions
MW5	A	28	34.0	35	100% LA	Machines for agriculture and food processing
MW6	K	28	32.6	17	100% LA	Water tanks, metal gates, metal doors
MW7	K	19	51.7	20	100% LA	Machines for food processing and woodworking
MW8	K	16	23.3	7	40% State 60% LA	Spare parts for vehicles
MW9	K	13	n.r.	29	50% LNA 50% LA	Fabricated mining equipment

Note: A = Accra; K= Kumasi, T = Tema.
Source: RPED Case Study Data, 1992.

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