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1
New Technologies and Economic Development

1.1 Introduction

In recent times, considerable empirical studies have been undertaken to understand the precise ways in which new technologies, particularly information and communications technologies (ICTs),[1] have contributed to the process of knowledge accumulation and more importantly, how this has promoted economic performance.[2] These studies have been carried out at different levels of aggregation, namely establishments and plants, firms, industries or sectors and countries. Strikingly but not surprisingly, most of the studies were carried out within sectors and firms in industrialized economies. Although the review (Seigel et al., 1997; Lichtenberg, 1995) shows a skewed distribution in the trend of studies, there have been efforts within developing countries themselves, by scholars working on developing countries as well as by the United Nations, to understand the role of ICTs in the economic development of countries (UNCTAD, 2001, 2002, 2004; Lal, 2002, 2001; Oyelaran-Oyeyinka and Adeya, 2004; Oyelaran-Oyeyinka and Lal, 2004). There are studies that examine the specific impact of ICT policies and in fact suggest that good ICT policies help develop e-business (Bridges.org, 2001; Dekleva, 2000; Wolcott et al., 2001; Mbarika and Byrd, 2003; UNECA, 1999). However, there are gaps in two respects, that this book addresses. First, many of these studies in developing countries are at a high level of aggregation that makes it difficult to understand the differential effects of critical variables on economic performance. Second, the available sectoral and firm-level studies focus on single countries addressing several sectors, making cross-country comparisons difficult. Even then there are hardly any systematic studies on enterprise-level adoption of e-business addressing the context of underdevelopment.

This book seeks to address the adoption of e-business at the level of the enterprise through cross-country comparative studies of three countries at different levels of economic development: Nigeria, Uganda and India. We approach the study by employing different quantitative and qualitative techniques that focus on the broad issue of the role of new technologies and how they contribute to knowledge creation and accumulation in the process of development. This is important because economic progress depends critically on the ways in which nations and firms accumulate technological knowledge through progressive learning. This study approaches the issues by collecting firm-level data through questionnaires and direct interviews with enterprise owners and policymakers. Recent empirical evidence in developed countries shows substantial and increasing returns on IT investment, contrary to many earlier inconclusive findings. The stylized facts are as follows:

1. At the level of the firm, there is 'strong evidence of excess returns' on IT systems, equipment and labour investments (Lichtenberg, 1995).
2. There is a strong relationship between IT and improvements in economic performance of the USA and the impact of IT on aggregate economic performance has increased over time (Stiroh, 2001).
3. However, externalities are equally important. That is, the complementary effects of investments made in R&D, computers and human capital in other areas of the industry and sectors reinforce, and could in fact be indispensable to, the observed positive impact on productivity in a particular sector. In other words, ICTs should be seen in the category of what some economists conceptualize as a 'general purpose technology' (GPT). A GPT exerts widespread and productivity-raising effects in all parts of the economy and sector.
4. There is a time dimension to IT investment because of the learning effect of technological investment within which firms master techniques and by which 'network effects' begin to be felt. Policymakers should therefore plan for lags in investment. For instance, adoption of advanced manufacturing practices may require significant changes in work organization that may sometime be disruptive while making positive impact on productivity (Siegel et al., 1997).

It is for these reasons that the studies that led to this book adopted a systemic approach to capture the nature of externalities affecting firm-level performance. Again, deliberately, the country samples were drawn from clusters of small and medium enterprises (SMEs)[3] because these are the dominant productive actors in the economies of developing countries. As

most recent literature has observed, new technologies open a new and powerful door of opportunity to SMEs to expand their markets beyond local and national borders. SMEs lower the transaction costs of information-intensive activities that involve far-distant and relatively sophisticated clients by employing Internet-mediated ICTs. In particular, ICTs have also emerged as significant shop-floor production tools by which firms develop flexibility and speed in manufacturing high-quality and specialized products. The adoption of new technologies employing high-speed computers coupled with advanced telecommunications technologies has not only resulted in relatively lower transaction costs but also promoted increasing intra- and inter-firm integration functions. Firms earn high profit margins not only through low wage and low skills production but also through fast delivery of customized products and services to customers. The scope advantage of small firms has been significantly enhanced by new technologies, be they manufacturers of batch orders or subcontractors to larger firms.

The book therefore presents preliminary evidence on the various ways of learning in firms in an Internet-based production environment but within a developing context characterized by skill deficiencies as well as weak institutional support. In short, the central research proposition in this book is this: to explore the determinants of the rate and types of ICT tools adopted by SMEs – coded as e-business in the country studies – in a developing context. In doing this we study the private and public institutions that compensate for the public goods shortcomings in these developing countries.

In what follows, we review the literature on the following set of issues:

1. Determinants of new technologies adoption
2. Learning, knowledge and innovation in development
3. Knowledge, skills and new technologies
4. The role of infrastructure in adopting ICTs
5. The Internet and the adoption of e-business technologies
6. Growth, employment and the adoption of e-business technologies

1.2 Determinants of new technologies adoption

ICTs have been applied across such diverse organizations and institutions as business establishments, non-profit organizations, educational institutions and governmental agencies. While the range and penetration of application of ICTs has evolved over the years, the rate of diffusion has been extremely rapid in some sectors. For instance, until the

early 1990s, the application of ICTs in educational institutions was limited mainly to complex computations in science, technology and mathematics and related departments. However, as the decade progressed, universities and academic institutions also adopted distributed computing, e-mail and open access to the Internet. The twenty-first century began with online access of databases and research output, and online learning. Similar developments have taken place with increasing complexity in the industrial application of ICTs across sectors.

In the 1980s, mainstream firms began to use in-house ICTs such as CAD/CAM and CAE, but through the 1990s, many of these same firms began to take advantage of the advances in ICTs and started using network technologies for intra-firm co-ordinating activities. Large corporations were able to connect distant production facilities to create greater networks and reduce transaction costs. During this period, firms developed and adopted several industry-specific ICT tools for this purpose. In the garments manufacturing sector, companies such as Gerber Garment Technology and Laser Lectra developed specific tools for marker making, fabric cutting and computerized embroidery. By the beginning of the twenty-first century, the adoption of ICTs for inter-firm commercial and non-commercial transactions was widespread.

While many manufacturing technologies have been industry-specific, business organizations and other institutions have applied networking technologies, including the Internet, on a general basis. Owing to the unprecedented developments in communication and Internet technology, new trajectories of network technologies have emerged, varying from the simplest forms, such as e-mail, to more complex forms, such as portal-based technologies. Although these technologies are not activity-, firm- or industry-specific, their adoption is influenced by firm- and industry-specific factors. Presently there is relatively widespread use of ICTs countries in all business activities by firms in developing, as well as developed.

In this book we examine the application of ICT tools within SMEs broadly as electronic commerce (e-commerce) and electronic business (e-business). The two differ substantially in content.

Before proceeding further, we therefore distinguish between e-commerce and e-business technologies. An OECD (2002) study examining the application of ICTs in commercial activities defines e-commerce as '… the sale or purchase of goods or services, whether between business, households, individuals, governments, and other public or private organisations, conducted over computer mediated networks. The goods and services are ordered over those networks, but the payment and the

ultimate delivery of the good or service may be conducted on or offline' (p. 89). This differs from e-business, a term that encompasses the application of ICTs in all business processes from office automation, production processes, co-ordination with other plants, customer relation management, and supply chain management to the management of distribution networks (Lal, 2004).

Broadly speaking, there are three modes of e-business transactions. These are offline, online and e-business using shared or individual portals. Offline e-business is enabled by electronic messaging systems, which are less effective than other forms of e-business tools. Offline e-business is normally done through e-mail systems while on-line e-business transactions take place with company web sites, although having a web site does not necessarily mean that an enterprise is able to process online e-business transactions. Web sites must be dynamic and should have online transaction facilities such as Active Server Pages (ASPs) that allow online transactions. The most effective way of doing e-business is through portals. Portals are essential additions in network technologies and fulfil an important role of aggregating content, services and information on the net. Broadly speaking, their function on the net is to mediate between users (buyers) and web content. This unique position enables portals to leverage marketing and referrals, as they are intermediaries between web users and companies.

Following the debate on the so-called productivity paradox in the early 1990s in developed countries and in the mid-1990s in developing countries, empirical studies of ICT impact showed the numerous benefits of ICT adoption. It has been demonstrated that the adoption of ICTs in general and e-business in particular leads to a reduction in co-ordination costs and promotes efficient electronic markets (Damaskopoulos and Evgeniou, 2003; Lee and Clark, 1997). Damaskopoulos and Evgeniou, in their study of East European and Cypriot SMEs, found that most of the sample firms (over 900) established their web sites to take advantage of cost reduction, to ease the search for new markets and to augment competitiveness. The study reported that 67 per cent of the sample firms in Poland and 86 per cent of those in Cyprus created their web sites for the reasons given above. The study concluded that '… e-business affects first the boundaries of the firm with the market in which it operates'.

Hodgkinson and McPhee (2002) examined the impact of the adoption by SMEs in Australia of web-enabled technologies on the export market development. A study by Teltscher (2002) deals with the fiscal implications of e-business, while Drew (2003) investigates the causes and consequences of the adoption of e-business by SMEs in the East of England.

Following an analysis of the total value of transactions conducted through electronic means and its implications for the fiscal policies of developing and developed countries, Teltscher (2002) observed that '… an increasing number of e-commerce businesses are small entrepreneurs …' and '… the fiscal impact of international e-commerce is likely to be felt more strongly in the developing countries….'. The findings of Drew (2003) suggest that SMEs are placing e-business at the centre of their technology strategy. The majority of the sample firms reported that the driving force behind e-business adoption has been opportunities for growth and the need to remain competitive. Hodgkinson and McPhee (2002) conclude that international networking by SMEs brought knowledge to the New South Wales regional exporting firms in Australia that facilitates intra-firm learning. The study further suggests that adoption of the Internet by SMEs is higher, albeit marginally (68.8 per cent), than by large firms (66.7 per cent).

In the context of developing countries, several studies (Moodley, 2002a, 2002b; Goldstein and O'Connor, 2002; Goldstein, 2002) have examined the adoption of e-business by manufacturing firms. Moodley (2002a) did not find sufficient evidence to support the argument that export-oriented apparel firms in South Africa gain more in adopting e-business due to its promise of improved market penetration and its direct link to international competitiveness. Moodley's (2002b) findings on the South African automobile industry are similar.

Goldstein and O'Connor (2002) summarized the findings of several studies and concludes '… as multinational corporations integrate the Internet into their cross-border business operations, firms from developing countries run the risk of exclusion from global value chains if they cannot establish electronic ties with their major business partners'. They also argued that, despite these general remarks, an evident need persists for detailed sectoral analysis of the adoption of e-business. A case study of one of the top automobile firms (Fiat) by Goldstein (2002) suggests that while the company has been very successful in optimizing supply-chain management in Brazil, it has not been able to do so in India. The study further reveals that the use of the Internet by the company in India (Fiat India) has been limited to knowledge management, R&D and marketing. In other words ICTs are differentially adopted depending on context specificity.

1.3 Learning, knowledge and innovation in development

Technological learning is the way organizations, such as the sample firms, accumulate technological capability (Malerba, 1992). Technological

capability is the knowledge, skill and experience necessary for firms to produce, innovate and organize marketing functions (Lall and Wignaraja, 1998; Ernst et al., 1998). Much of the technological knowledge required by small and medium firms in the early stages of development in developing nations is incremental and can often be acquired through what is described as 'elementary learning' (Lall, 1982), although there are exceptions within firms that have moved up in the supply chain. As firms climb the ladder of manufacturing complexity, the types of knowledge they require, the nature of their organization and the forms of institution to support them become increasingly complex. In the past decade, we have come to know much more about the nature of learning and capability acquisition in firms, and in what follows we provide a brief overview.

First, learning in firms is a major source of incremental technical change, and as such a firm is a learning organization, and through the knowledge it accumulates, it continually transforms its knowledge assets to foster higher orders of operation (Lundvall et al., 2002; Malerba, 1992).

Second, following from above, a firm is characterized by a certain level of technical and organizational knowledge base. Third, a firm draws upon a wide variety of knowledge sources (suppliers, subcontractors, machinery suppliers) that may be within its locale or, often, outside the national boundary (Lundvall, 1988; Von Hippel, 1988).

Fourth, there are different modes of learning, of which learning by doing and learning through research and development (R&D) are only some of these sources. Learning by doing is by definition a costless, effortless process, which does not often lead to innovation. Learning efforts cannot lead to dynamic productivity gains without explicit investments that alter the technical and organizational assets of the firm.

Fifth, learning processes are linked to specific sources of technological and productive knowledge such as apprenticeship, equipment manufacturing and others. Sixth, learning does not take place in a vacuum and firms do not innovate in isolation. External actors with which firms interact are crucial to learning in firms. The sources of external knowledge by which firms internalize new capabilities range from equipment suppliers and input suppliers to universities, to research institutes, while the role of private business associations, as suppliers of knowledge, has become crucial. Learning processes are linked to the trajectories of incremental technical change through the accumulated stocks of knowledge in firms (Malerba, 1992). In other words, the direction of technical change is related to the types of learning process. The different types of learning identified in the literature are learning by doing

(Arrow, 1962), learning by using (Rosenberg, 1982), learning by searching and R&D (Dosi et al., 1988), learning by interacting (Lundvall, 1988; Von Hippel, 1988), learning by operating (Teubal, 1987; Scott-Kemmis and Bell, 1988), by changing (Katz and Ablin, 1987), system performance feedback (Bell et al., 1988), by searching and training (Dahlman and Fonseca, 1987) and, finally, by hiring (Katz and Ablin, 1987).

1.4 Knowledge, skills and new technologies

For a number of developed and developing countries, empirical literature shows evidence of continuous development of skilled workers, particularly those with tertiary education, over time. However, contrary to the conventional wisdom, underpinned by the demand and supply argument that wage inequality will be attenuated by an increase of skilled workers, the wage inequality between skilled and unskilled workers seems to be growing (Piva et al., 2003). This assumption draws on historical evidence dating from the Industrial Revolution when machines and low-skilled labour replaced the artisan. Underlying this change is the emergence, diffusion and use of knowledge, particularly scientific and technological knowledge that has reached its full manifestation in the new technologies of ICTs and biotechnology.

The form (that is, digitally coded information), content and the way we use different forms of technological knowledge have been transformed by rapid changes brought about by new technologies, while the mechanisms of skills transfer have been altered significantly by advances in microelectronics. The new competition (Best, 1990) as well as the changes in the economic context, particularly the liberal regimes of trade and production, are equally significant factors (Lundvall and Johnson, 1994; Johnson et al., 2002; Ducatel, 1998). There is renewed debate on the most appropriate mix of skills and the most important sources of knowledge accumulation in a new knowledge-driven economic context. Discussions are likely to continue on how to assign relative weights to formal and non-formal knowledge in firms, and the underlying conceptual dichotomy of tacit and codified knowledge.

Despite the burgeoning empirical evidence from the highly advanced countries, we are far from a full understanding of the most important determinants of the 'skill bias effect' often associated with both technological and organizational changes. According to the notion of 'skill bias effect', the rising skill content of the labour force is due to the accelerating rate of technological change, wherein technological change induces the demand for better educated and skilled workforce (Arrow,

1962; Nelson and Phelps, 1996).[4] Sectors that experience rapid technological progress would be inclined to hire workers who are more educated because this group has far less need for training in basic skills and constitutes a ready innovation asset within firms. The corollary is that technological change will in turn stimulate the demand for more knowledge-intensive and skilled labour. There is a preponderance of evidence of a positive association between the rate of technological progress and the demand for an educated workforce. Berman et al. (1994), working at the sectoral level, found positive correlation between R&D and skilled labour in the United States. Bartel and Lichtenberg (1987) also showed, using industry level data, that manufacturing industries in the 1960–80 period exhibited greater relative demand for educated workforce in sectors with newer vintages of capital.

In addition to the technology-induced skill effect, organizational change also seems to underlie the changing skill composition of firms. Introducing ICTs, for example, tends to change the ways decisions are made within organizations by 'flattening' hierarchies and promoting greater involvement of the workers in management (Caroli, 2001). Facilitation of greater interaction as well as information exchange at the factory level would tend to promote worker productivity. However, while the evidence is mixed regarding the productivity-enhancing impact of ICTs, there is greater evidence of the nexus of new technologies and the emergence of new forms of organization[5] (Brynjolfsson and Hitt, 1998). What this implies is that firms have to manage technological and organizational changes simultaneously, putting a demand on the resources required for technical, skill and organizational upgrading. As Guellec (1996) observed, 'Human capital and technology are two faces of the same coin, two inseparable aspects of knowledge accumulation. To some extent, the same can be said for physical capital. Accumulation of these factors goes hand in hand with innovation: one does not accumulate billion dollars of wheelbarrows or train millions of people as stonecutters. Only the appearance of new devices makes it worthwhile to invest and train.'

Developing countries are not insulated from, and indeed have much more to lose if they do not engage in, the debate to find ways to survive in the new environment of rapid technological and organizational changes. There are two reasons for this. The first is that all societies, regardless of their level of development, need to process and use knowledge. As Metcalfe (2003) observes, 'Every economy, always and everywhere, is a knowledge economy; for social systems and economies as social systems, could not be arranged otherwise.' The second reason

stems from the well debated notion that the growth, validation and transfer of knowledge is a socially distributed process mediated by institutions (Lundvall and Johnson, 1994; Metcalfe, 2003; Ducatel, 1998). However, institutions of knowledge in developing Africa are weak, and in most cases absent. Small firms often lack the resources for innovation and tend instead to concentrate on achieving the nominal production capacity with which daily routine is ordinarily concerned.

In transforming codified global digital knowledge to local use, only a portion can be transferred by formal technology transfer mechanisms; the rest often requires a long heuristic process of imitation, reverse engineering, learning by doing and apprenticeship. Stiglitz (1999) termed these processes of learning 'horizontal methods of knowledge transfer', while the formal, codified storable mode is called 'vertical transfer'. These largely practical informal methods can take several forms.[6] Despite the increasing propensity to codify technical functions, tacit knowledge remains an important component not only in the context of traditional sectors and small firms, but also as a necessary cognitive basis for interpreting codified knowledge, including digital and mathematical functions. In contrast, formal learning is characterized by five distinct characteristics: it has (1) a prescribed framework; (2) an organized learning package or events; (3) the presence of a designated teacher or trainer; (4) the award of a qualification or credit; and (5) the external specification of outcomes (Eraut, 2000). However, building institutions for formal knowledge accumulation is costly and time consuming, and poor countries often lack the resources to sustain them.

The clear importance of tacit and codified knowledge highlights the dichotomy of formal and non-formal institutions. As Stiglitz (1999) argued, developing countries need to formulate effective ways to promote *local knowledge institutions* because evidently 'the overwhelming variety and complexity of human societies requires the localization of knowledge'. There is a clear distinction between global public goods and local knowledge, and for this reason every society should be active in strengthening local knowledge institutions to drive the local learning process.

1.5 The role of infrastructure in adopting new technologies

Physical infrastructure comprises energy supply, water, telecommunication and transport systems (roads, railways, airfreight etc.). Notably, physical infrastructure tends to function poorly in developing countries leading in many instances to investment in alternative facilities such as

boreholes and electrical power generating sets. This tends to raise the production cost as well as the price of goods and services, thereby depressing demand. A rise in the quality of infrastructure could be productivity enhancing; where such a change is negative or cost escalating, either the quality deteriorates or prices of utilities rise.

Technological infrastructure proxies with ICT infrastructure, which may be divided broadly into three components: telecommunications, computing and connectivity infrastructure.

Connectivity infrastructure has four components: (1) the aggregate bandwidth of the domestic backbone(s), (2) the aggregate bandwidth of the international IP links, (3) the number and type of interconnection exchanges and (4) the type and sophistication of local access methods. Internet penetration, defined as pervasiveness, represents the number of users per capita, which proxies either the Internet hosts counts or individual users. The pervasiveness of Internet use is a function of among others, access to services, perceived value to users acceptable costs to users, and ease of usage, which depend crucially on content language. Finally, the structure of the Internet service providers (ISPs) market is an important factor influencing access. The presence of ISPs, and the institutional regimes in which they operate, is also important to market competitiveness, and as such it involves a cost to end users. For instance, Internet diffusion may be slow where state policies create barriers to ISP entry, or where cultural limitation leads to persistent disparity between girls' and boys' education, or where security concerns create a regime hostile to competition. Access at the individual level is achieved using modems at early stages of development, while more sophisticated infrastructure, such as leased lines, is used in later stages of development.

National, local and regional telecommunications infrastructure include server connectors, local loop telecommunication lines, internodal connections and switching systems, among others, and determine the cost and quality of access. Users in high-bandwidth telecommunications environment are likely to have access to lower cost connections. Most developing countries face capacity constraints, largely as a result of thin bandwidth and frequent power outages. At the very basic level, developing countries exhibit highly differentiated access to telephone and electricity services, which in developed countries are taken as a given. The quality of the physical and technological infrastructure is important for the simple reason that information, coded in files, travel through a series of linked nodes within the ICT network.

Table 1.1 Distribution of mean value of variables by the intensity of Internet use (2000)

Variables	Intensity of Internet use		*F*-statistics	Level of significance
	Low	High		
EDU	2.604 (2.33)	4.23 (4.33)	2.11	0.155
GDP	381.61 (334.57)	1452.2 (1642.9)	8.14	0.007
IH	0.18 (0.22)	6.51 (12.35)	5.28	0.028
ITI	0.02 (0.34)	6.36 (10.40)	5.98	0.020
IU	10.71 (6.48)	130.83 (199.67)	7.64	0.009
PCDEN	2.94 (2.39)	21.01 (26.72)	8.19	0.007
TELEDEN	5.44 (3.07)	46.06 (66.79)	6.29	0.018

Note: Figures in parenthesis are standard deviations. EDU, education; GDP, gross domestic products per capita in USD at 1995 level; IH, internet hosts per 10,000 persons; IU, internet users per 1,000 persons; PCDEN, personal computers per 1,000 persons; TELEDEN, telephone lines per 1,000 persons; and ITI, investment in telecommunications infrastructure.

The slowest link in the network node becomes the rate-determining step and thereby defines the overall speed of data transmission (Dholakia, 1997).[7]

In a separate study, Oyelaran-Oyeyinka and Lal (2005) showed the relationship of the different infrastructure variables to the process of wealth creation. Table 1.1 shows an Internet user index (IUI) that we relate to the technological infrastructure variables, namely telephone, PCs and Internet host. The aim is to demonstrate the strong correlations of the three infrastructure capitals, although the direction of causality is not always easy to establish.

The variables were analysed by classifying all Sub-Sahara African countries based on their relative density of Internet users. In this case, the groups were also categorized on the basis of the median value of the density of Internet users, that is, 19 persons per 10,000 inhabitants. Descriptive statistics of variables, along with significance of group mean differences are presented.

The table shows the EDU, measured as the ratio of enrolment at the tertiary level of education to the total eligible persons, does not differ significantly between the two groups. The table also shows the high significance level of many of the variables. For instance, PC density and income level of countries in both the groups differ significantly (1 per cent). The significance level of the remaining variables, that is, IH, ITI and TELEDEN, is at the 5 per cent level. However, it is difficult to draw any conclusive inference from the table for two reasons: first, the statistics presented in the table are based on the data for only one year and,

second, the results are based on univariate tests that exclude the interaction of other variables. Therefore, we explored the relationship between Internet users and the most significant variables in the univariate analysis. The trends are presented in Figures 1.1–1.3.

Figure 1.1 presents the relationship between the density of Internet users and the economic wealth of Sub-Sahara African countries. The figure shows that per capita GDP is an important determinant of Internet diffusion. The R^2 of a trend line between Internet users and GDP is 0.62, which indicates a strong explanatory power of GDP in influencing use of the Internet. Sixty-two per cent of the variance of the dependent variable is explained by GDP per capita. This confirms similar findings cited earlier.

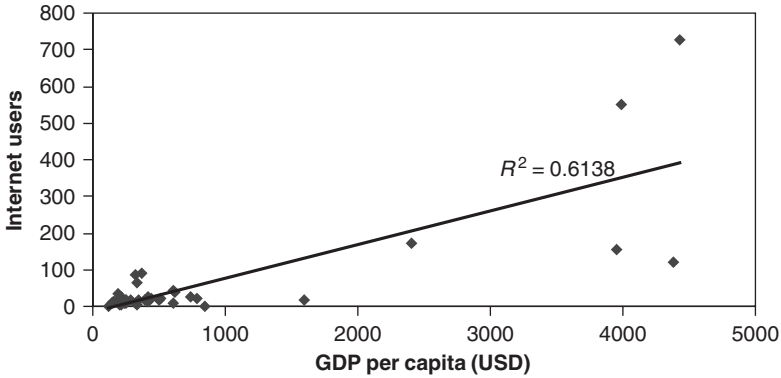

Figure 1.1 Internet users and GDP per capita in USD (2000)

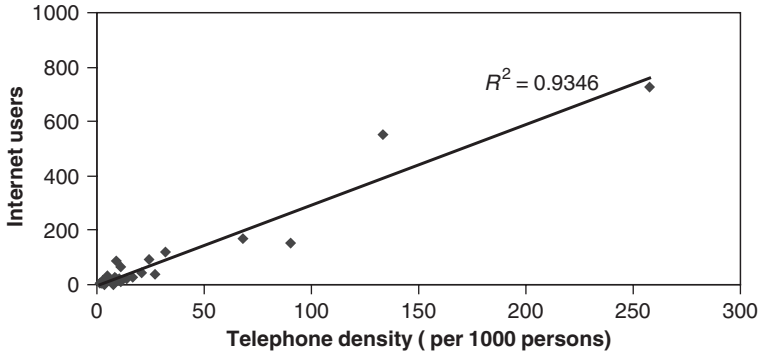

Figure 1.2 Internet users and telephone density (2000)

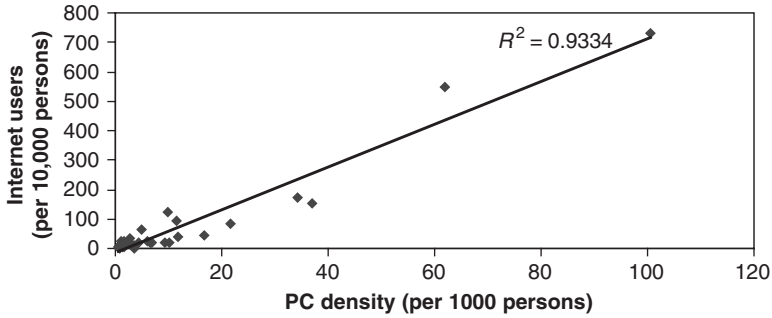

Figure 1.3 Internet users and PC density (2000)

Similarly, Figure 1.2 presents the relationship between use of the Internet and last mile connectivity in Sub-Sahara African countries. Last mile connectivity is the connection between end-user and the server of the Internet service provider, which is the telephone line in most of the Sub-Sahara African countries. The value of R^2 of the trend line between these variables is 0.93, which is very high. In other words, 93 per cent of the variance of the dependent variable is explained by telephone density.

We conclude from Figure 1.3 that telephone density is more important than GDP in explaining the variation of Internet diffusion in the sample countries when they are analysed separately in a single equation framework. However, their relative importance might change in the multivariate model, which we carried out in a paper (Oyelaran-Oyeyinka and Lal, 2006) cited earlier.

The mean values of PC density also emerged as significantly different in low- and high-Internet using countries. The relationship between these variables, depicted in Figure 1.3, therefore validates the statistics presented in Table 1.1. The very high R^2 (0.93) of the trend line between these variables suggests that the explanatory of PC density is also very high.

The graphs shown in Figures 1.1, 1.2 and 1.3 are based on data for the year 2000. The trend depicted in these figures may not remain the same once the data are analysed for other years. To obtain a more robust relationship between the diffusion of the Internet and other macro variables, the data were analysed using the simultaneous equation approach.

The following paragraphs summarize the output of the analysis carried out in a simultaneous equation framework.[8] The parameters of the model were estimated using pooled data, as well as each year separately (1995–2000). The model consists of three equations. They are labelled

as Internet diffusion, infrastructure and communication network equations and represent the spectrum of our three infrastructure capitals.

The Internet diffusion equation identifies the factors expected to influence Internet diffusion directly. The second equation examines the role of existing telephone density and per capita investment on telecommunication infrastructure, while the third equation investigates the role of economic wealth and the density of Internet users in influencing telephone density.

The findings of the study suggest that the density of Internet hosts and personal computers significantly influence Internet diffusion and confirm earlier univariate analysis. The emergence of these variables as important determinants is not surprising because the possession of a computer is a necessary condition for Internet access. A large number of Internet hosts facilitates more efficient and effective use of the Internet. The results support the findings of Oyelaran-Oyeyinka (2002) that concluded that ease of accessibility to the Internet was a significant factor in its diffusion in Nigerian universities.

The results also show that a lag of even one year's investment in telecommunications infrastructure as well as the existing telephone density are important determinants of the density of Internet hosts that in turn influences use of the Internet. These findings are not surprising and support the findings of earlier studies (Hargittai, 1999; Kelly and Petrazzini, 1997). Given the gestation period of these technologies, a one-year lag, rather than the current value of investment in the telecommunications network, can emerge as significant. Despite Kiiski and Pohjola (2002) having used an alternative measurement of last mile connectivity, their results are akin to that of this study with regard to the importance of telephone density in influencing Internet use.

The study captures the significant role played by economic wealth in stimulating the diffusion of the Internet. Similar results have been found by almost all the studies that examined the predictive role of GDP per capita. The role of economic wealth becomes more relevant in the case of ICTs because governments need significant investment capital for a reliable and efficient communications network in order to experience a faster diffusion of these technologies. National and global communications networks are not possible without sufficient economic wealth.

1.6 The internet and the adoption of e-business technologies

The current literature argues that the adoption of ICTs leads to significant reductions in co-ordination costs and to efficiency gains in electronic

markets (Malone et al., 1987; Lee and Clark, 1997). Almost every nation searched for alternatives to paper-based methods of information communication and storage in the last quarter of the twentieth century. The Internet has arguably been at the forefront of recent development in the application of ICTs and is possibly the most pervasive of the ICTs. The use of the Internet cuts across application fields such as business, education and governance as well as geographical boundaries. Its wide application has attracted the attention of social scientists, who have examined the causes and consequences of Internet adoption. A study by Kiiski and Pohjola (2002) analysed the diffusion of the Internet in OECD countries and using data for 1995–2000. The authors found that GDP per capita and access cost were the main factors that influenced Internet diffusion in this group. A study of 47 developing countries (Biliamoune, 2002) used Internet hosts, Internet users, personal computers and mobile phones as indicators of ICTs diffusion and found that income levels and trade policies were the main determinants of the diffusion of ICT.

A comparative study of the diffusion of Internet use in China and India by Press et al. (2003) identified six dimensions that led to the differential growth of the Internet in these countries: pervasiveness, geographical dispersion, organizational infrastructure, connectivity infrastructure, sectoral absorption and sophistication of use. Broadly categorized in these six dimensions and using data from various years as indicators, the authors identified comparative advantages in 1999 and 2002 of aspects such as Internet users and hosts; its applications in education, government and health; availability of national and international bandwidth; telecommunications competition; international gateway competition; and co-ordinating organizations. They conclude that although India has significant advantages in the use of the Internet in governance, telecommunications competition and international gateway competition during 1999–2000, China continues to have a substantial lead in the diffusion of the Internet.

1.7 Growth, employment and the adoption of e-business

Concern about the employment effects of ICTs has been apparent since the early stage in the development of ICTs and their adoption in various economic activities. While many view ICTs as a major cause of mass unemployment, others believe that ICTs create many new jobs and give rise to new industries and services (Talero and Gaudette, 1995). In the early stages of ICT adoption, there was considerable apprehension that the adoption of these technologies might result in reduced levels of employment, particularly of semi-skilled or unskilled workers. This view

underlined the programmability feature of ICTs and their capability in handling multiple tasks with a single ICT tool. Therefore, the perception emerged that the adoption of ICTs had a negative effect on employment. It is still believed that ICT tools replace certain categories of workers and lead to a significant rise in unemployment levels. The reasoning has some validity, particularly at the enterprise level with respect to existing manufacturing processes.

The adoption of ICTs in labour-intensive activities is expected to result in the displacement of labour, while creating a few jobs for the skilled workers needed to maintain the ICT tools. The adoption of ICTs may be labour-neutral if there is a possibility of market expansion for existing products or the possibility of creation of markets for new products manufactured on the same assembly lines due to the extensive use of ICTs. This may apply at the enterprise level, but its application at higher levels of aggregation is likely to be even greater. In the presence of possible market expansion, the adoption of ICTs could lead to creation of employment for skilled workers; if the market expands fast enough, there may not be a loss of jobs for unskilled workers. However, to use ICT tools effectively, firms may need to effect organizational changes and workers may require training to upgrade their skills. The findings of several studies that deal with employment aspects of ICTs are presented below.

Rada (1982) and Kuwahara (1984) found that the adoption of IT at the enterprise level leads to new jobs in some production processes and a loss of positions in other activities. The authors also found evidence of the emergence of firms with new activities, which usually fall within the sector, but outside the existing enterprises. For instance, several new consultancy firms have emerged in the garments sector to provide technical input and technological support to garments manufacturing firms. Although they provide consultancy services in other manufacturing technologies in the garments sector, their main activities are to provide training and consultancy services in the new ICT-based technologies.

Freeman and Soete (1985) found no evidence of an adverse relationship between employment and the adoption of IT. Their conclusions are based on several other studies (Leontief and Duchin, 1983; Kuwahara, 1984; Lawrence, 1984) carried out in developed countries (USA, Canada and Japan). The study by Leontief and Duchin (1983) is a very comprehensive one, analysing 89 individual sectors comprising almost the entire industrial spectrum of the US economy. They conclude that there will be no overall labour surplus as a result of the adoption of IT at the industry level, even though employment in some individual enterprises may suffer.

However, the study predicted that the structure of the labour force, in terms of skills and sectoral distribution, might have to undergo some fundamental changes. A study by Lawrence (1984) finds a positive correlation between the industrial adoption of IT and employment growth in Japan.

Peitchinis (1984) studied the employment effects of the introduction of computer equipment and office automation in a number of Canadian manufacturing sectors, ranging from food to oil companies. The author rejected the prediction of mass unemployment as a result of IT adoption. On the contrary, his case studies, based on firm-level data, suggest that the employment effects of IT adoption have generally been positive. The results were found to be more relevant for firms where the demand for their products was not saturated and there was a possibility of production capacity expansion. Firms could generate employment by increasing production capacity and by the adoption of IT. The author, however, observed that in mature industries there could be employment displacement because of IT adoption. Although the firms covered by Peitchinis were engaged in manufacturing goods, the study concentrated mainly on the introduction of computer equipment in office automation. Therefore, the results cannot be interpreted as representative effects of IT adoption in manufacturing.

A study by Kuwahara (1984) emphasizes the positive employment-generating effects of a range of new technologies in the Japanese economy. Although these new technologies include biotechnology and aerospace, the main emphasis is on IT. The study views microelectronics-based technologies (technologies used to manufacture hardware of information systems, communications equipment, audio/visual devices and other electronic products) and IT as having creative multiplier effects in other industries and services. The study presents detailed estimates of job creation effects in high-technology industries in Japan, and presents the estimates categorized into various skills levels. The findings suggest that engineers are likely to be in greater demand than non-technical workers in high-technology industries. Several other studies (Rada, 1982; James, 1994; Rahim and Pennings, 1987) proposed the possibility of structural change in employment. Rada (1982) found evidence of a reduction of jobs at the supervisory level. At the same time, IT tools require a highly skilled workforce for the implementation and use of microelectronic-based systems (Ayres, 1991; James, 1994). Developing countries (DCs) have experienced similar employment effects of IT. Acero (1995) reported changes in employment structure in a study of the Brazilian textile industry. She found that industrial automation and new organizational technologies are seen as contributing to higher

employment levels in the technical and managerial category, while the number of occupational categories and labour-intensive tasks decreases with the introduction of IT. Sim and Yong (1995) found similar results in their study of the Malaysian telecommunications industry.

Doms et al. (1997) examined the correlation between the ratio of non-production to production workers and the use of advanced technology. The authors found a positive correlation between two variables, consistent with the complementarity of skill intensity and advanced technology use. A study of 402 plants in Britain by Kramarz (1998) suggests that the introduction of computers in plants is associated with an increase in the share of white-collar workers at the expense of unskilled workers. Card et al. (1997) investigated the effect of computer use on the employment rates of various age and education groups. Based on their knowledge of the institutional environment of the three countries (USA, Canada, France), they expected the greatest negative impact of IT on employment to be in France. Their hypothesis was that if a similar negative demand shock affects less skilled workers in all three countries, then given the labour market flexibility in the US, the shock should result primarily in a decline in the relative wages of less skilled workers. In France, where labour markets are relatively inflexible, the shock should largely result in a decline in the relative employment of less skilled workers. However, the results do not seem to show this pattern. In the US, results show that groups, categorized by age and education, that use computers most intensively record an increase in group-employment rates. In France (female workers) and Canada, there is no significant relationship between computer use and employment. The US results are based on data extracted from Current Population Survey (CPS) of 1979 and 1989, while Labour Force Survey (conducted in 1982 and 1989) data were used for France. The data for the Canadian sample come from the Survey of Work History (1981) and Labour Market Activity Survey (1988).

1.8 Outline of the chapters

Chapter 1 introduces the objective of the book and reviews the empirical literature on the different factors that influence how SMEs adopt new technologies. Chapter 2 presents the methodological framework that includes the process of sample selection and the characteristics of the various industrial clusters.

Chapter 3 examines the impact of industry-specific factors on the intensity of ICT adoption in business applications. Adoption of a new

technology is influenced not only by industry-specific factors, but also by the level of the country's economic development. Nigeria, Uganda and India are at different levels of technological and economic development and the thrust of policies are therefore different in respect of e-business adoption. The data we collected indeed reflect how significantly their need and capacity for technological absorption differ, and necessarily, we analyse the data for each country separately. Furthermore, since the intensity of e-business tools adoption differs significantly in each country, we could not adopt a uniform categorization of e-business tools across all the three countries. Lastly, while we have wide sectoral variations, this provides a basis for a rich comparative analysis across countries in this chapter.

Most of the studies analysing the causes and consequences of e-business adoption have selected firms controlled for their size-of-operation and product mix. Given the paucity of such studies in developing countries, we analysed the factors that influence the adoption of internal e-business technologies in Chapter 4. What constitutes internal and external e-business technologies is discussed fully in the chapter. The chapter classifies clusters of firms on the basis of choice of technology, identifies factors that result in the adoption of a particular technology and analyses these factors within a multivariate econometric framework. The algorithm requires information on the number of clusters and based on the known characteristics, computes a composite index. The criteria for convergence are such that the variance of the composite index within a cluster is minimal and the variance between the clusters is maximal. We found considerable differences in the types and levels of technologies utilized in firms and across countries even after controlling for sectoral differences.

In Chapter 5, we present evidence of learning processes and investment at the enterprise level. We advance three main theses. First, that there is clear evidence of increasing complexity in the adoption and use of ICTs among developing country firms. Second, that climbing the technological ladder requires skills upgrading through explicit learning of new technologies, and for this reason the rate of ICT adoption in developing nations has been highly differentiated. Third, that firm performance is highly associated with learning capabilities, levels of technology, and a host of firm-level knowledge, skills and experience. In a novel attempt, the chapter statistically tests different learning mechanisms using both Ordinary Least Square (OLS) and bivariate distribution of firms based on the technological trajectories that firms follow.

The main objective of Chapter 6 is to identify and analyse supply side factors that support the adoption of e-business by SMEs. They are made up

of physical and technological infrastructure available to SMEs. While the intensity of adoption of e-business tools differs considerably in each country, the nature of support shows a common strand. Institutional structures are meant to support firms using e-business technologies in production as well as in other activities such as marketing, co-ordination and after sales. The tools employed in production processes comprise mainly computer-aided design/computer-aided manufacturing (CAD/CAM), computer-integrated manufacturing (CIM), flexible manufacturing systems (FMS) and computerized numerically controlled (CNC) machine tools. Firms use e-mail, Internet and web-enabled and portal-based technologies for transaction processing and co-ordination of activities. Almost all the sample firms in India were using office automation technologies such as management information systems (MIS) and local area networks (LAN).

Chapter 7 identifies four important factors identified in our study that tend to be closely associated with the adoption of e-business: the potential business activities in which e-business technologies can be adopted; the availability of reliable and affordable ICT infrastructure; the potential gains expected from e-business and the impediments associated with e-business in a developing context. It is difficult to cover all these aspects in one study; we therefore focus on a limited number of objectives in this chapter:

1. factors that discriminate advanced users of e-business technologies from others;
2. the impact that the perception of management has on the adoption of new technologies;
3. the impact of the competitive environment on the diffusion of e-business technologies;
4. the role of the institutional environment in the growth of e-business; and
5. the role of collective actions in the diffusion of e-business technologies.

Chapter 8 addresses an issue of enormous importance that has, however, received scant attention: the implication of adopting new technologies by SMEs in a labour surplus economy, such as India. The study examines the direct and indirect impacts on employment of the production and adoption of ICTs in India. The case of India is relevant because the country has made significant progress in global software production on the one hand and is facing serious unemployment problems on the other. A long-time data series is needed to examine meaningfully the impact of ICT adoption on employment; however, it is

extremely difficult to collect data on workforce[9] for a long period of time. Hence, we have used the case study method to address the issue of employment and new technology adoption in business organizations. Since the effect on employment is expected to be sharper in large firms, we have selected a number of top firms within the skill- as well as labour-intensive sectors. While investigating the effect on employment, we have also taken into consideration the employment generated by the production of e-business technologies. In this chapter we present case studies of high-performing firms in related subsectors, namely e-business technologies (that is, ICT sector), consumer electronics and the garments manufacturing industry.

Several studies have demonstrated the importance of technological differences in international trade. The studies suggest that non-price factors, such as product quality and product differentiation, exert a significant influence on international competitiveness. Chapter 9 documents our findings on how new technologies impact the export performance of SMEs. New technologies have been widely adopted by various types of firms engaged in the manufacturing and service sectors, in both developed and developing nations. The justification has been based on the perceived links between ICTs and gains in productivity, improvement in product quality and increased flexibility in manufacturing processes. This chapter addresses factors that determine the adoption of ICTs using case studies of Indian firms, and in doing so we analyse the consequences of the use of e-business practices on firms' export competitiveness.

Our preliminary finding is that e-business fosters organizational innovation, enabling firms to enter new and changing markets. Through e-business, companies reshape their market presence and the manner in which customers buy their products and services. Through the use of ICTs, firms can reach new customers more efficiently and effectively, thereby transforming the mode of exchange of goods, services, information and knowledge.

Chapter 10 draws conclusions and policy implications, as well as signals directions for future studies.

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