Chapter 1
General Introduction

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1.2 Research Problem, Importance, Relevance and Method

Economists have long recognised the essential role of technical progress in the creation, acceleration and sustainability of economic growth and improvement of the quality of life in any society. Both the endogenous growth theories and empirical literature acknowledge the importance of human capital accumulation for economic growth. Endogenous growth literature also elaborates on the interaction and complementary relationship between technological progress and human capital to create, reinforce, accelerate and sustain economic growth (cf. Lucas 1988; Romer 1990; Freeman and Soete 1997). Moreover, economists also highlight the role of high levels and quality of skills as critical factors for competitiveness associated with the rapid progress of globalisation and fast technological progress in developed and developing countries. Considerable debate in the literature is on the effects of human capital and the diffusion and transfer of technology to developing countries to accelerate the catching-up process. For instance, the Nelson and Phelps (1966) model allows human capital levels to affect the speed of technological catch-up and diffusion. Romer

The study presented in this book refers to Sudan before separation.

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(1990) has also argued that the level of human capital may have an influence on growth of technological innovation both directly and through its effect on the speed of the catch-up process. Benhabib and Spiegel (1994) adapted the Nelson and Phelps (1966) framework to allow for the catching-up of technology with that of the leading countries. In their view, the level of education not only enhances the ability of a country to develop its own technological innovations, but also its ability to adapt and implement technologies developed elsewhere.

Endogenous growth theory predicts that in the long run economic growth at the aggregate level is determined by endogenous sources of technological change: human capital, learning by doing, spillovers of knowledge and the external effect of human capital. Endogenous growth literature revealed several robust facts and interesting implications that paved the way for growth and it also provided some insights for a possible role for government policy. The literature on endogenous growth and public policy presents an argument for government intervention to promote the accumulation of technology, human capital and hence growth rate. The most popular view in the literature is that the rationale for government intervention is basically related to the idea that knowledge (in the form of technical progress or accumulation of human capital) is a public good, which is non-rival and partially excludable. As in Romer (1990) and Barro and Sala-i-Martin (1995) these two features imply unbounded growth and incomplete appropriability of knowledge, and raise the possibility of knowledge spillovers across firms and hence the whole economy. While the feature of spillovers of knowledge supports endogenous growth, it also creates a form of externality and implies that private investments generate a positive external effect and the private returns from investment tend to be lower than the social returns. The outcomes tend not to be Pareto optimal but suboptimal that require government intervention to correct the distortion; the social optimum can be achieved by many instruments, such as providing subsidies to improve the accumulation of technology and human capital. In the endogenous growth literature some studies explicitly model the importance of technology and human capital for endogenous growth but only implicitly indicate a role for public policy. For instance, while the Lucas (1988) model emphasises investment in human capital, it only implicitly allows for a role for public policy by subsidies (Haslinger and Ziesemer 1996: 230). Moreover, the Arrow (1962) learning-by-doing and Romer (1986) models imply an indirect intervention: an investment tax credit that increased the accumulation of capital necessarily also increased the accumulation of technology (Romer 1990: S94).

According to Ziesemer's (1987) interpretation, T. W. Schultz (1964) presents a pioneering theoretical justification for central role for government interference to promote public investment and emphasis their long run effects on growth and development. The theory of Schultz (1964) reveals that the provision of public factors, such as basic education and basic scientific research, is necessary for human capital formation and this would drive technical progress. Therefore, technical progress depends on human capital and the production of human capital requires public factors, such as basic education and basic scientific research financed through a linear income tax rate. Several studies emphasise a role for government intervention and a positive impact of public provision of education and training

(cf. Azariadis and Drazen 1990; Barro and Sala-i-Martin 1992, 1995; Jones 1998; Chatterji 1995; Haslinger and Ziesemer 1996; Otani and Villanueva 1990; Ziesemer 1990, 1991, 1995).

Few studies examine the practical relevance of the models of growth enhancing policies, particularly for developing countries. For instance, Haslinger and Ziesemer (1996) indicate that most of the models of publicly financed investment in human capital are basically intended for industrialised not developing countries. In their view, in developing countries, raising the publicly financed investment is hampered by the lack of well-developed institutional setup to use the instruments of taxation, mainly because of substantial engagement in non-monetised activities, large informal sectors, extreme poverty and different effects from the prevalent regressive trade tax (Haslinger and Ziesemer 1996: 240–241). Given these practical limitations for developing countries, in the recent years there has been a growing body of literature on the role of public policies and government intervention to promote human capital and technological capabilities in developing countries. For instance, Lall (1999) discusses strategies to develop skills, technology and capabilities in developing countries and identifies autonomous (Korea and Taiwan) and foreign direct investment (FDI)-led targeted strategy (Singapore and Malaysia) and the FDI-led market-led strategy (Mexico and Thailand) (Lall 1999: 9, 10).

In this research we use the framework of and perspectives from the new growth literature to investigate the relevance and importance of skill upgrading and technological development, and the interaction between these for economic development in Sudan. The importance of the country increased after the recent exploitation of its oil. In recent years the increasing dependence on oil has led to high fluctuation in economic growth, for instance, the gross domestic product (GDP) growth rates increased from 6 % in 2003 to 10.5 % in 2007; however, the global financial crisis and related shock in 2008 and 2009 resulted in low global oil prices, stagnating domestic oil production and caused a reduction in GDP growth rate that dropped from 10.5 % in 2007 to 7.8 % and 6.1 % in 2008 and 2009 respectively. While oil has recently contributed to the improvement of the country's economic performance, the recent heavy dependence on it may lead to serious challenges for Sudan since oil is an exhaustible resource and – because of the instability of oil prices – revenue from oil is uncertain and volatile. Moreover, the increased wealth from oil encourages migration to the country, consequently, migrant workers may start to replace domestic workers and so contribute to unemployment in the labour market in the country.[1]

The GDP and GDP per capita of Sudan are still growing, but their annual growth rates are either stagnant and/or have even declined. So far, the country suffers from serious political instability and serious conflicts, in addition to several serious

[1] For the empirical investigation in this research we focus on Sudan as a case study of the Arab countries, due to easy accessibility to data, information and facilities for the fulfillment of the fieldwork. According to the World Bank classification, Sudan is amongst the lower medium income, least developing and heavily indebted countries.

economic problems such as high rates of inflation and unemployment and a high incidence of poverty. Over the past years, the increasing contribution of the oil sector has been used to improve the country's economic performance, but, in our view, the big question is whether or not this will work in the future. We feel this may be somewhat doubtful in light of the recent current stagnation in education, particularly tertiary education and also because of the negative impact and loss of most of the oil reserves (70 %) and oil revenues (50 %) following the official secession of Southern Sudan. In addition, the high share of foreign capital indicates that Sudan is currently an attracting economy. But it may lose this position and become even poorer if both the oil industry and the complementary ones decline and/or if foreign capital moves out and there is less work in the government sector. Notwithstanding these structural shifts, and whether the agriculture sector will remain the country's main driver of the economy or the services and industrial sectors can fill the gap, it is evident high levels of education will be needed. Therefore, it is quite essential for the government to improve investment and enrolment in education and skill upgrading.

The economic growth and sustainable development strategy in Sudan depends on both a shift in the focus from an oil resources-based economy to a technology and skill-based economy and to economic diversification. A key part of this strategy is also to achieve peace and political and economic stabilisation, to reduce unemployment and poverty, and to manage the economy away from dependency on the import of technology and high skilled workers in favour of domestic skilled workers. Overcoming these strategic problems and challenges confronting economic development and thereby achieving long run economic growth and sustainable development in Sudan, depends on five main strategies: alleviation of poverty; achieving economic diversification; reducing unemployment and restructuring the labour market; building local technological development and enhancing self-reliance on domestic capital and workers and achieving stabilised, sustained and balanced economic growth and development strategies. In our opinion the success/fulfilment of these strategies is contingent upon the development of adequate and appropriate skills, skill upgrading and efficient educational and training policies and building of local technological capabilities in Sudan.

In our view, although the development of local technologies is a costly process and likely somewhat problematic to be funded from the oil revenues in the short term, notably in light of the loss of 50 % of Sudanese economy's oil reserves after the official secession of Southern Sudan, but the development of local technologies can be encouraged by offering further incentives to motivate private investment in skills, technology and technical education. Moreover, to some extent, Sudan has an option to remain importing technologies and to specialise in fields other than producing machinery and transport equipment (SITC 7). Sudan shows poor technology achievement index, deficient skill and technology indicators and a substantial gap when compared to rapidly advanced countries (cf. Lall 1999; UNDP 2001). Therefore, the need for the development of local skills and building local technologies are important not only for fulfilling the above strategies, but also for shortening the gap, building local capacity, improving productivity and competitiveness in the international market.

In our view, the implementation of these strategies is eminently impeded by the deficient educational system, the serious skills mismatch and the lack of incentives in Sudan. One should note that many previous studies in the Sudanese literature have thoroughly investigated the causes and implications of the serious problems and improper political and economic performance (cf. Awad 1991a, b; Ali 1990). However, the impacts of the deficiencies in the educational system and serious skills mismatch have not received adequate investigation in these studies, despite the well-known stylised facts in the endogenous growth literature that highlight the essential endogenous effect of education for accumulation of human capital and economic growth.

For that reason, our analysis in this research provides many new and interesting results. Different from other studies in the Sudanese literature (Al-Sanousi 1999; Beshir 1969; Suleiman 2007; Jalal al-Din 2002), we identify upskilling as a key element for the fulfilment of the five current strategies in Sudan. Furthermore, we provide a more comprehensive investigation since we discuss the skills problem from two different perspectives: combining the impacts of the deficient educational system and the high incidence of unskilled workers. In addition, our analysis goes beyond the available Sudanese literature and presents a more elaborate and in-depth analysis to assess skill and technological performance in Sudan since we use a very comprehensive set of indicators that is often used in the new growth literature. We use these indicators to analyse the causes and consequences of low skill and technology levels, the link between them and the implications for skills mismatch, and the lack of local efforts for technological development and the consequent dependence on foreign technologies at both the macro and micro levels. In addition, in light of the recent literature that highlights the role of diffused technologies, our analysis uses a broader definition of technological change that considers the role of diffusion in fostering economic growth and we assess the role of imported technologies in promoting local technologies and local skills. This definition is particularly relevant for our analysis since Sudan is highly dependent on imported technologies and recently relatively on imported skilled workers to manage them. Our analysis also addresses the policy issues, stresses the role of both public and private educational and training policies and the need for incentives, harmony and collaboration between public-private institutions in upgrading skills and fostering human capital accumulation in Sudan. Finally, our analysis fills the gap in the Sudanese literature since we highlight the importance of knowledge and external effects of schooling/the transfer of knowledge, and we explore the factors hindering and those contributing toward enhancing the transfer of knowledge at both the macro and micro levels.

Moreover, our research contributes to the few recent studies in the Arab region that call for upskilling and the interaction between skills and technology (Muysken and Nour 2006; Nour 2005a, b). We explain the deficiencies in the educational and training systems, their impacts on declining industrial performance and on skills mismatch (Al-Sulayti 2002; Gray 1999; Abdelkarim and Haan 2002; Suleiman 2007;

Jalal al-Din 2002). We show the impacts on poor technological level that dependence on foreign technologies and the impacts of technologies transfer (El Sabaa 1997; Haan 1999), macro–micro duality concerning knowledge transfer, upskilling and training policies.

To investigate the research problem we focus on Sudan as a case study of the Arab countries and we use the descriptive, comparative and statistical methods of analysis, and we use a combination of primary and secondary data covering both the macro and micro levels and the results from the macro and firm surveys (2010) that were held in Sudan in 2010. In addition, the surveys data was supported by ten face-to-face interviews with firm managers and five interviews with the officials. The firm survey (2010) on 'Technological Change and Skill Development in Sudan's Manufacturing Sector' aims to assess skill and technology indicators and the impacts of unskilled workers amongst the food, textile, chemical and metal small, medium and large size establishments in Sudan. The macro survey (2010) on 'Skill Creation, Human Resources Development and Policy Intervention' was sent to policy makers and experts in public and university institutions to examine the causes and consequences of low skills and the deficient educational system in Sudan. In addition, we conducted the R&D Survey (2010), which is small survey on research and development (R&D) based on 25 face-to-face interviews with officials policy makers and experts in the government and academic staff in the public and private universities, to examine the causes and consequences of poor R&D activities at the macro level. All primary and secondary data were collected personally.

1.3 Objectives, Hypotheses and Questions of the Research

Based on the above background, the central themes of this research are: the required skill formation and upskilling of the workers, together with their interaction with technological change; and the deficient educational system and their implications. First, our analysis aims to provide an empirical investigation of the causes and consequences of low skill and technology indicators, in particular, the causes and consequences of the deficient educational system and the implications of the serious skills mismatch at both the macro and micro levels. Second, we examine the interaction between the low skill and technology indicators, the relationships between skill, upskilling and technology indicators, skills mismatch, the uses and impacts of ICT and differences, defined by firm size (small, medium, large) and industry (food, textile, chemical, metal), at the micro/firm level. Third, we examine the factors hindering and those contributing toward enhancing the transfer of knowledge/external schooling effects at the macro and micro levels. Finally, we highlight the need for implementation of consistent policies, increasing incentives and collaboration between public and private educational and training institutions to enhance skill upgrading, local technological development, economic development and transfer of knowledge.

Grounded on these objectives, our research attempts to answer three sets of questions:

1. What are the major causes and consequences of low skill and technological levels in Sudan? What are the major implications of the deficient educational system and the high incidence of unskilled workers at the macro–micro levels in Sudan?
2. Does the external effect of schooling/transfer of knowledge occur in Sudan? If not, why does it not yet occur? What are the major factors hindering and those contributing toward enhancing the transfer of knowledge at both the macro and micro levels in Sudan?
3. What are the major policies for upgrading skill, reforming the educational system, enhancing the provision of training and the development of local technologies at both the macro and micro levels in Sudan?

Based on the research questions and objectives, the major hypotheses to be tested in this research are:

1. Sudan needs to promote local skills and local technologies in order to implement the five strategies of reducing poverty; achieving economic diversification; reducing unemployment and restructuring the labour market; building local technological capacity; and achieving long-term stabilised, sustainable and balanced economic growth and development.
2. In the short- and medium-term, Sudan is unable to rely on local technologies and will remain heavily dependent on foreign technologies.
3. (a) The interaction between the deficient educational system and the high incidence of unskilled workers leads to low skill and technology levels and many other serious implications.

   (b) The deficient educational system is caused by low quality of education and leads to: (1) poor provision of training; (2) low skill levels; (3) skills mismatch; (4) low transfer of knowledge/external schooling effect; (5) weak technology indicators; (6) dependence on foreign technologies at the macro and micro levels and (7) poor industrial performance at the micro level.

   (c) The major causes of low levels of local technology are low/lack of R&D activities due to a lack of funding, skills, transfer of knowledge, networks and collaboration between universities and industry/firms.

4. (a) The observed differences in actual and required skill levels, i.e. the high skill requirements and the prevalent low skill levels (due to high share of unskilled workers) lead to skills mismatch and contribute to industrial performance and productivity decline at the micro level/across firms.

   (b) An increase in skill level (share of highly skilled in total employment and in firm size) leads to improved relationships between actual and required education and experience and wages.

(c) An increase in skill level (share of highly skilled in total employment and in firm size) leads to improvements in the complementary relationships between skill, upskilling and technology (ICT).

5. The use of ICT has positive but insignificant/inconclusive effect at the micro level/across firms.
6. The transfer of knowledge/external schooling effects is unsuccessful at the micro and macro levels. The major reasons behind the low transfer of knowledge/external schooling effects are low educational qualifications, and deficient educational and training systems. The major consequences are the lack of networks and collaboration between universities and firms, low R&D efforts and low technology indicators.
7. Knowledge has positive impacts at the macro–micro levels; it can be enhanced by many factors.

   (a) At the macro level codified knowledge and tacit knowledge are positively correlated with economic growth (GDP growth rate) and are positively correlated with schooling.
   (b) At the macro level codified knowledge (the total spending on R&D) and tacit knowledge (the total number of full time equivalent researchers (FTER)) are positively correlated with each other and also with technology (patents).
   (c) At the micro (firm) level tacit knowledge is positively correlated with technology (Information and Communication Technology (ICT)), upskilling (training), profit, productivity, output and output diversification.
   (d) At the micro (firm) level tacit knowledge is positively correlated with market size (firm size; capital; and investment) and firm age.

8. Sudan needs to enhance both the public and private educational and training policies:

   (a) Skill development depends on: (1) reforming the educational system; (2) enhancing the provision of training; (3) planning skill needs and matching educational output with market needs; (4) enhancing the transfer of knowledge/schooling effect; and (5) incentives and collaboration between public and private institutions.
   (b) The promotion of local technology and adoption of appropriate foreign technologies and the interaction between both to foster economic growth in Sudan depends on skill development. In particular, an enhancement of: (1) skill upgrading: educational and training systems; (2) R&D activities; (3) the transfer of knowledge/schooling effects; (4) network systems; and (5) incentives to motivate collaboration between universities and firms and between public and private institutions.
   (c) Both upskilling policies (educational and training policies) and transfer of knowledge are consistent at both the macro–micro levels and across public-private sectors.

1.4 Structure of the Research

Considering the research problem, aims, questions and hypotheses presented above, it is convenient in this Chapter to set out the structure of the research. This research is composed of four parts and ten chapters structured in the following way. Part I presents the introduction and motivation of the research and includes both Chaps. 1 and 2. Chapter 1 presents an introduction and briefly shows the aims, importance, relevance, hypotheses, questions and the general structure of the research. Chapter 2 explains some stylised facts about Sudan that help to investigate more extensively the research problem along with other strategic problems and challenges confronting economic development, the impacts of oil and the Dutch Disease phenomenon in the structure of the labour markets and economy. In addition, this chapter aims to examine the structural problems related to the labour market and unemployment problem and to assess and elaborate the low skill indicators and to show some stylised facts that justify and highlight the need for skill upgrading and development in Sudan.

Part II presents the conceptual and theoretical framework and includes Chap. 3, which defines the concepts and describes the measures of technological change and human capital (education) and briefly explains the theoretical and empirical literature on the relationship between human capital, technological changes and economic growth. The purpose of this survey is to provide a background for our study, mainly to highlight the endogenous effects of technical change and human capital as confirmed in the endogenous growth literature to motivate the empirical analysis in the next chapters.

Part III presents the empirical application and includes Chaps. 4, 5, 6, 7 and 8. Chapter 4 defines the methods of data collection; identifies the motives for performing the macro and firm surveys and selection of a case study; specifies the selection of the sample and the composition, operation, coverage, advantages and limitations of the survey data; and shows the structure and design of the questionnaire. Chapter 5 uses the data and results from the firm and macro surveys to examine the serious implications of the interaction between the deficient educational system and skills mismatch. We use the results from the macro survey to show the causes of the deficient educational system and consequences on low skill levels, poor provision of training, skills mismatch and lack of/low transfer of knowledge at the macro level. In addition, we use the results from the firm survey to illustrate the implications of the high incidence of unskilled workers on causing low skill levels, poor provision of training, skills mismatch, poor technology indicators and a heavy dependence on foreign technologies. Furthermore, we investigate from the micro–macro perspectives the transfer of knowledge, upgrading of skill and technology and their potential implications, and we also present a more comprehensive assessment of technology and skill indicators at the micro level. Chapter 6 extends our analysis in Chap. 5 by assessing and elaborating the low skill and technology indicators at the macro level; explaining the gap in Sudan compared to developed and developing countries and showing some stylised

facts that justify and highlight the need for skill upgrading and technological development in Sudan. Chapter 7 aims to broaden our analysis in Chaps. 5 and 6 by providing an in-depth analysis of skill and technology indicators, the relationship between them, and the implications of the prevalence of low-skilled workers on skills mismatch and poor industrial performance at the micro level. We use the data from the firm survey (2010) to examine the relationships between skills (actual and required education and experience) and wages; between skill, upskilling (ICT training) and technology (ICT); and between technology (ICT) and input–output indicators across firms. We also compare the relevance of our results to the theoretical framework in Chap. 3 and the findings concerning these relationships in the new growth literature. Chapter 8 extends our analysis in Chap. 5 on the transfer of knowledge. We use the data from the firm survey (2010) at the micro level and some secondary data at the macro level to discuss the importance/impacts of knowledge in Sudan. In particular, we check the relevance of some stylised facts about the importance/impact of knowledge at the micro–macro levels to the findings in knowledge literature.

Finally, Part IV presents the policies, recommendations and conclusions and includes Chaps. 9 and 10. Chapter 9 concludes our analysis by discussing educational and training policies, since our earlier analysis in Chap. 5 investigates the causes and consequences of deficient educational and training systems, the lack of knowledge transfer and upskilling, and the results set in Chaps. 7 and 8 imply the importance of a good education. From that perspective, therefore, Chap. 9 discusses the supply–demand sides and the implications of educational and training policies in Sudan. In addition, we use the results from the macro and firm surveys (2010) to examine the macro–micro views and suggestions for relevant mechanisms and policies for skill upgrading via an enhancement of the educational system, provision of training and transfer of knowledge/external schooling effects at the macro–micro levels in Sudan. Finally, Chap. 10 summarises and compares the main findings with the results in the general literature and contributions to the Sudanese literature and concludes with policy recommendations.

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