Chapter 10
Summary and Conclusions

This concluding chapter summarises the major findings and contributions of the research. Sect. 10.1 briefly identifies the research problem and the major findings of the research; in Sect. 10.2 we show the relevance of the research findings to the general literature and contribution to the Sudanese literature; and, finally, Sect. 10.3 presents short outlines on policy recommendations.

10.1 Research Problem, Methodology and Major Findings

This research is composed of four parts and ten chapters: Part One includes both Chaps. 1 and 2 and presents the introduction and motivation of the research; Part Two contains Chap. 3, which presents the conceptual and theoretical frameworks; Part Three comprises Chaps. 4, 5, 6, 7, and 8 and presents the empirical application; and finally, Part Four encompasses Chaps 9 and 10 on policies, recommendations and conclusions. We explain below the main findings of each chapter.

Chapter 1 presents a brief introduction that gives a general overview of the research problem, its importance, relevance, objectives, questions, hypotheses and the structure of the research. We explain that the central themes of discussion in this research are the required skills formation and upskilling of the workers, together with their interaction with technological change in Sudan. In particular, we intend to provide an empirical investigation of the causes and consequences of deficient educational system, their interaction with the excessive share of low educated workers and their implications on skill levels, skills mismatch, transfer of knowledge, provision of training, level of local technologies and dependence on foreign technologies. In addition, we aim to present an indepth macro-micro analysis to assess technology and skill levels using a more comprehensive set of indicators.

Following the identification of the research problem in Chap. 1, we then present the background that motivated the research in Chap. 2. In particular, we show some stylised facts about Sudan, to examine the research problem more extensively, along with other strategic problems confronting economic development in Sudan.

We explain that oil greatly contributed to economic development in Sudan by satisfying domestic consumption and achievement of self sufficiency, increasing government and public revenues, rapid and impressive economic growth as measured by the growth in the GDP and its composition and structure, increasing foreign direct investment (FDI) and increasing the volume of foreign trade as measured by the volume and structure of exports. We find that however, the recent heavy dependence on oil, may lead to negative impacts and serious challenges for Sudan since oil is an exhaustible resource and because of the instability of oil prices in the international market the revenue from oil is uncertain and volatile and may lead to instability of economic growth. Moreover, the increasing dependence on oil leads to increasing debate for and against the incidence of the Dutch Disease phenomenon in the Sudanese economy, the lack of diversification and the challenges related to potential north-south conflict and division of the country. Hence, economic growth and sustainable development strategy in Sudan depends on economic diversification, which in turn is contingent upon the availability of adequate and appropriate skills and technologies.

We also illustrate the other serious structural problems in Sudan that relate to the Dutch Disease, structural imbalances in the labour market, poverty, unbalanced development strategy, growing unemployment, slowdown in economic growth and declining labour productivity. We illustrate the low skill and technology indicators and the substantial gap prevalent in Sudan when compared to the world's rapidly advanced countries. In our view, Sudan needs to upgrade skill levels and encourage the development of local technologies to narrow the technological gap and achieve economic development in Sudan. In particular, skill upgrading is imperative to facilitating economic diversification, restructuring the labour market, enhancing productivity of labour, lessening dependence on foreign workers and, consequently, poverty and unemployment in the labour market. Skill upgrading through enhancing educational and training systems is essential to facilitate the adoption of appropriate foreign technologies in the short run, and to encourage the development of local technologies through encouraging R&D activities to reduce the technological gap and dependence on foreign technologies in the long run. Therefore, our findings in Chap. 2 confirm our first hypothesis in Chap. 1 above that Sudan needs to promote the local skill and local technologies to face the challenges created by the depletion of oil resources. Sudan needs to implement the three strategies of diversification, building local technological capacity and restructuring the labour market. Our results confirm part of the second hypothesis in Chap. 1 above that in the short- and medium-term, Sudan is unable to rely on local skills and local technologies and remains heavily dependent on both foreign skills and foreign technologies at the macro level.

In light of the findings in Chap. 2, it becomes more plausible to highlight the need for improvement of education or skill upgrading and the development of local technologies or technological progress to facilitate economic diversification and ensure long run economic growth and sustainable development in Sudan. Before commencing with the empirical analysis, Chap. 3 briefly explains the concepts, measures and theoretical and empirical literature in relation to human capital

(education), technological change and economic growth. We provide a background for the empirical analysis in the subsequent chapters by surveying the theoretical and empirical literature that emphasise the positive endogenous growth effects of technical change and human capital in increasing and sustaining economic growth. We explain that economic growth theories recognised and provided different perceptions and analytical frameworks for modelling the various effects of technical change, innovation and human capital on economic growth. The major differences arise because exogenous growth theories perceive and model technical progress and human capital as exogenous variables in growth accounting model, while, in contrast, the endogenous growth theory envisages and models technical progress and human capital as endogenous variables determining the rates and differences of economic growth across countries. The endogenous growth theory contributes towards improving the understanding of the interaction between technological change, human capital and economic growth and fills the gap in earlier growth theories by considering the important endogenous effects of human capital, technological progress and innovation. It also 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 external effect of human capital. The presence of increasing returns to scale and externalities prevent diminishing returns to the accumulation of capital and thereby ensure the steady state of growth in the long run. 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 sub optimal and they require government intervention to correct the distortion using various instruments, such as providing subsidies (which can be financed by taxation) to improve the accumulation of technology and human capital, the incentives and returns from investment for private investors. We illustrate that the inclusion of human capital and technological change in growth accounting models motivate the endogenous growth literature to provide several interesting explanations of the relationship between human capital and technical progress. In particular, it stimulates considerable debate about the complementary relationship between human capital and technical progress, skilled biased technical change, the role of technical progress in skill upgrading and the role of skills and improvement in the accumulation of human capital in skill upgrading. These explanations imply that next to the important endogenous effects of technical progress and human capital in economic growth, the complementary relationships amongst and between them and skill upgrading are also important for enhancing economic growth. Finally, we show the advantages and limitations of various measures of technological change and human capital that have been used in the theoretical and empirical literature, and we then select the most relevant measures for our empirical analysis in the subsequent chapters according to the availability of data.

We consider the endogenous growth framework as a useful background for the empirical investigation in the following chapters. Before we go into the empirical analysis, we define the methods of data collection including both surveys and

interviews in Chap. 4. We utilise the surveys data in our analysis and use the descriptive, comparative and statistical (OLS regression) methods of analysis. We explain that the basic objective of performing the macro and firm surveys is to obtain specific information to provide insights into the factors influencing or the causes and consequences of low skill and technology and to help to generate policies to improve skill and technology at the macro-micro levels. The macro survey examines the causes and consequences of the deficiency of the educational system and the firm survey discusses the implications of the excessive use of unskilled workers. The field research to collect our primary data was held in the period from January to June 2010, in Sudan as a case study of the Arab countries. The selection and focus of our analysis on Sudan was related to the easy accessibility to data and information and facilities for the fulfilment of the fieldwork/surveys, which were offered by the Department of Economics, Faculty of Economic and Social Studies at the University of Khartoum. Moreover, the case of Sudan is both important and interesting as in recent years, Sudan shows significant increase in terms of ICT diffusion and shows rapid increase in the net inflow of foreign direct investment, for instance, Sudan is the fourth country in Africa and fifth in the Arab regions in terms of attraction of foreign investment.

In Chap. 4 we explain the selection of the sample, its composition, operation, coverage, advantages and limitations of the survey data, and show the structure and design of the questionnaire. The firm survey (2010) on 'Technological Change and Skill Development' covers 100 of the small, medium and large size firms working in four industries in the manufacturing sector: the chemical, food, metal and textile industries. The selection of these four industries was based on many reasons, the most important of which is that the argument for both upskilling and technological upgrading is promising in these four sectors and can be used to reduce poverty and unemployment problems in Sudan and also due to the important contribution of these sectors in total output, value added, capital investment, employment, exports, imports and number of industrial establishments in the manufacturing sector. The sample in the firm survey was drawn from the small, medium and large size firms active in the chemical, food, metal and textile industries, which are located in Khartoum state. The selection of Khartoum state was based on its significant and highest average share in total employment, capital investment and total number of factories and industrial establishments engaged in the chemical, food, metal and textile industries and also because the manufacturing industries in Khartoum state are characterised by being more diversified compared to other states in Sudan. The macro survey (2010) on 'Skill Creation, Human Resources Development and Policy Intervention' was sent to 40 of policy makers and experts in 8 public, university, educational, training and research institutions in Sudan. The number of respondent firms and policy makers are 87 and 36 respectively. In addition to support the firm and macro surveys we collected primary data by conducting interviews and small survey on R&D based on 25 face-to-face interviews with the official policy makers and experts in the government and the academic staff in the public and private universities. The main purpose of this survey is to collect primary data to investigate the causes and consequences of poor R&D activities,

to examine the main factors hindering and those contributing towards the promotion of R&D and to give recommendations to improve R&D and S&T in Sudan.

The data from the firm and macro surveys provide us with the required information, which is particularly useful for presenting a macro-micro comparative analysis to identify the causes and consequences of the skills problem and the policies for skill development from macro-micro perspectives. The results of the macro survey seem quite representative, since the selection covers governments, universities, and educational and training institutions. One advantage of the macro survey is that it examines the problem after integrating the two different perspectives of policy makers and experts and also integrating two different perspectives from both the fields of education and training. The results of the firm survey are also quite representative, since the selection and coverage of firms in the survey includes a broad range of firms working in the chemical, food, metal and textile industries, which provides us with relevant data and information that is of considerable use in our analysis. Such coverage also has the advantage of enabling us to compare between firms according to two criteria: the size of employment and the industrial activity. One major limitation with respect to the firm survey is the low response rate for some questions, especially when the answers or data required quantitative measurement. Such problems arise because some of the respondent firms were unwilling to provide complete and reliable quantitative data, while others offered somewhat selective answers.

Apart from this limitation, the data from the firm and macro surveys remains useful, not only for the empirical investigation in Chaps. 5, 6, 7, 8 and 9, but also for the policy analysis and suggestions in Chap. 9. We begin our analysis in Chap. 5, by using the results from the macro and firm surveys to verify our third hypothesis in Chap. 1 above, about the serious implications of the interaction between the deficient educational system and the high incidence of unskilled workers. In particular, the results from the macro survey show that the deficient educational system is attributed to many causes such as the poor quality of education that leads to many serious consequences including low skill levels, poor provision of training, skills mismatch and low transfer of knowledge at the macro level. In addition, the results from the firm survey illustrate that the excessive use of low educated workers leads to several serious implications such as low skill levels, poor provision of training, skills mismatch, poor technology indicators, weak adaptation of imported technologies and a heavy dependence on foreign technologies. Our findings from the surveys and follow-up interviews indicate that the poor technology indicators/indigenous capability to build the local technology and heavy dependence on foreign technology can be attributed to low skill levels, lack of R&D activities, weak linkages, lack of networks systems, and low transfer of knowledge. These findings at the micro level seem consistent with those at the macro level.

Chapter 6 shows the status of S&T input and output indicators at the macro level in Sudan; it explains that the combination of poor S&T inputs/resources together with an inadequate economic system as a whole results in Sudan producing poor S&T outputs/performances. Moreover, we find that most R&D and S&T activities

and FTER employment in Sudan occur within the public and university sectors, while the private sector and industry make only a minor contribution. When comparing the same S&T input and output indicators of Sudan with those of the Arab countries and world's other developed and developing countries, our findings indicate that Sudan lags behind in terms of most S&T input indicators (both financial and human resources). That also holds for the average share of high-technology exports, GDP per capita growth, number of scientific publications, level of share in international publication and number of patent filings. Our findings indicate that despite the important role of R&D in satisfying the needs for economic development, development of local technologies and adaptation to imported foreign technologies. However, the contribution of R&D seems to be constrained mainly by the lack of finance to cover the high costs of R&D as the main problem, moreover, the lack of human resources (researchers and qualified workers in R&D fields) is also mentioned but of somewhat less importance. We find that from the policy makers and experts' perspective the main problems hindering R&D include: the lack of finance from public sector; lack of management and organisational ability; lack of coordination and weak relationships, networks and consistency and cooperation between universities and higher education institutions on the one side and the productive sector (agriculture, industry, services) on the other side; lack of R&D culture; lack of finance from the private sector; lack of favourable conditions and the necessary facilities; lack of awareness and appreciation of the economic values of R&D, and lack of human resources (researchers and qualified workers in R&D fields) respectively.

When distinguishing between firms according to firm size and industry level, we find that skill and technology indicators show considerable variation across firms. Our findings show one surprising contradicting macro-micro view. Notably, the contradicting optimistic-pessimistic micro and macro view regarding the incidence and success of knowledge transfer/external schooling effect implies that the transfer of knowledge/the external effects of schooling is probably successful within firms, but is unsuccessful within society at large. This is probably because the transfer of knowledge is hindered by: the low quality of education; the weak linkages and a lack of networks between universities, colleges, technical and training institutes and the productive sectors; the incidence of high illiteracy rate; and incidence of high mismatch between educational output of population and labour market. Our observation show a consistent optimistic macro and micro view, concerning the self-reliance on local skill and the role of both technological upgrading and upskilling in reinforcing it, implies that the self-reliance strategy is probably not only a preferred government strategy but probably is also one followed by private firms. Though driven by profit-maximising considerations, private firms are likely to continue in hiring cheap readymade skilled workers rather than in hiring, training and upskilling workers with expensive costs. From these observations, our results accept hypothesis 8.c. in Chap. 1 above about the consistency of upskilling and transfer of knowledge at the macro-micro levels. These results corroborate a part of the sixth hypothesis in Chap. 1 above with respect to the failure and the factors hindering the transfer of knowledge/external schooling effects at the macro level

and also corroborate part of hypothesis 8.c. in Chap. 1 above about the consistency of upskilling at the macro-micro levels. But, on the other hand, our findings surprisingly reject a part of the sixth hypothesis concerning the failure of the transfer of knowledge/external schooling effect at the micro level, and also reject part of hypothesis 8.c. in Chap. 1 above about the consistency of the transfer of knowledge at the macro-micro levels.

The surprising results from Chap. 5 motivate our research to attempt a more comprehensive analysis of skills problem and the implications of unskilled workers at the micro level/across private firms. Therefore, in Chap. 7, we then use the data from the firm survey (2010) to broaden our earlier analysis in Chap. 5 by providing an indepth analysis of skill indicators, their implications and relationships with wages, upskilling (ICT training) and technology (ICT) indicators at the micro/firm level. Our findings illustrate the low skill levels – due to the excessive share of unskilled workers - and the implications on skills mismatch, and industrial performance indicators and productivity decline across firms. These results are consistent with the micro-macro findings in Chap. 5, which indicate the low share of high skilled workers in total population and employment (measured by both educational and occupational levels) and the serious implications for skills mismatch. Furthermore, we show that difference between required and actual education indicates severe skills mismatch across all firms and all skill levels, especially, across high and low skilled workers respectively and across medium, small, chemical, food and metal firms respectively. These findings, together with those in Chap. 5, verify hypotheses 3 and 4.a in Chap. 1 above regarding the implications of low skill levels and the argument, earlier in Chap. 2, about the pressing need for upskilling, mainly in the private sector.

Our results show positive correlations between skill (actual and required education, experience and its square) and average wages. We show that differences in skill levels/stock of human capital (share of high skilled in total employment) across firms are related to market size (share in total employment, capital, output/sales and profit). We also find that an increase in skill level (share of high skilled in total employment) and firm size lead to improved relationships between actual and required education, experience and its square and wages. Next, our results show positive complementary relationships between technology (ICT), skill and upskilling (ICT training). We illustrate that an increase in skill level (share of high skilled in total employment) and firm size lead to improved in the complementary relationships between skill, upskilling and technology (ICT). The relationships between skill indicators and wages and between skill, technology (ICT) and upskilling (ICT training) substantiate our fourth hypothesis (4.b–4.c) in Chap. 1, and agree with the findings in Chap. 5 concerning the differences in skill and technology indicators across firms according to firm size and industry. These results imply the importance of good education/skill levels for bridging differences between firms and also for improving skills, technology and upskilling complementarity at the micro level.

These results guide us in Chap. 8 to use the firm survey (2010) data at the micro level and secondary data at the macro level to examine and verify hypothesis 7 in

Chap. 1 above concerning the importance/impacts of tacit and codified knowledge at the micro-macro levels respectively. We find that at the macro level, tacit knowledge and codified sources of knowledge are positively and significantly correlated with both schooling years and GDP growth (economic growth rate). Moreover, we find that at the macro level codified knowledge and the number of FTER show positive correlations with technology (patents). Furthermore, our results at the macro level show significant positive complementary relationships between codified knowledge and the number of FTER, which we interpret as a complementary relationship between tacit knowledge and codified knowledge. Moreover, at the micro (firm) level, we illustrate the importance of tacit knowledge, and we illustrate that tacit knowledge is positively and significantly correlated with technology (expenditures on ICT) and upskilling (expenditures on training), output (defined by total sales value), output diversification, productivity and profit. In addition, we find that at the micro (firm) level, tacit and codified knowledge show positive significant correlations with total investment, capital, and firm size. The major implication of our findings is the positive correlation between knowledge and various variables at both the micro and macro levels. Therefore, further incentives should be provided to improve tacit and codified sources of knowledge at the macro and micro levels. Another implication is that the positive impact of tacit knowledge also implies the importance of a good education since tacit knowledge is often embodied in educated people and so in human capital.

In view of the findings in Chaps. 2, 3, and 5, 6, 7, 8, which indicate the importance of a good education, in Chap. 9 we use the data from the firm and macro surveys to conclude our study with policy analysis. We corroborate hypothesis 8 (8.a–8.b) in Chap. 1 above concerning the need for skill and technological upgrading through the reform of the educational and training systems and the transfer of knowledge. Moreover, we use secondary data and information and the macro and firm surveys (2010) to present a policy analysis of the educational (supply-demand sides) and training systems in Sudan. We show that the educational policies in Sudan and Arab and Gulf countries share several problematic features such as an insufficient duration of compulsory education, the dominance of public sector and the lack of incentives/marginal contribution of the private sector on educational investment. Additional problems include poor quality, insufficient demand (enrolment ratios), an insufficient supply (spending) and the biased structure of tertiary education. However, despite these similarities, we also observe enormous variations, particularly with respect to the supply and demand sides of educational policies. Differences in the supply side include financial resources or priority of public expenditures on education relative to GDP and total government expenditures, allocation/distribution of public spending and investment at various educational levels, human resources or availability of teaching staff and the extent of privatisation. Differences regarding the demand side include enrolment ratios and outcomes or implications on literacy rates, access to schooling/school life expectancy and interaction with training. We find that the priority of investment in education, as measured by public expenditures on education as a percentage of total government expenditures and priority of investment as a percentage of GDP in Sudan lags far behind the level prevalent in the Arab and Gulf

countries and the level of developed countries. When comparing supply-demand sides, it turns out that the supply side or public spending seems to be only one component in educational policies, because higher private spending in tertiary education per se does not lead to higher demand, participation, access and enrolment ratios in private tertiary education, which shows moderate private spending, but low demand/enrolment ratios, most probably because of high cost of private tertiary education and high poverty rates in Sudan. We observe that while the educational policies in Sudan, Arab and Gulf countries have raised enrolment ratios and literacy rates, they have failed to show satisfactory outcomes with respect to access to schooling/school life expectancy and training. This is due to serious deficiencies concerning the quality of education, coupled with the serious problems of biased structure and inadequate spending and enrolment in tertiary education in these countries. Hence, the major policy implication from our results is that the improvement of the educational policies in Sudan, Arab and Gulf countries is vital and requires an improvement in the quality/internal efficiency, in the supply (investment) and demand (enrolment) sides, particularly in tertiary and technical education, and encouraging private sector investment in education.

Our results show the low commitment to the standardised international adequacy, equity and efficiency criterion related to the supply and demand sides of educational policies. We explain the low commitment to the standardised international adequacy criterion on the supply side that implies the allocation of less than 8 % of GDP on education and less than 20 % of total government or public spending on education and on the demand side that implies the adequacy in intake and enrolment rates in primary and secondary education, gender equity in enrolment in education and literacy rate of population. Furthermore, we then discuss the low commitment to the standardised international equity criterion, which implies the lack of equal distribution and allocation of financial resources to achieve the balance between the different education sectors and between different geographical rural and urban areas. Moreover, we then examine the low commitment to the standardised international efficiency criterion which implies that the low efficiency often appears from the low rates of attendance, high rates of dropout, high rates of repetition, weak rates of success in final exams, low rates of trained teachers and over-crowded classrooms as indicated by the rate of students enrolment per education institutions. Moreover, we explain that it is probably plausible to interpret the observed regional disparity in the share in demand and enrolment in education due to three important determining factors or reasons, notably, the demographic reason (as measured by the share in total population), economic reasons (as measured by per capita income and poverty rate) and other reasons (as measured by the degree of urbanisation) across the main regions in Sudan. Our results imply that the increase in the incidence of high poverty rate and the low per capita income seem to be the most important factors determining, limiting or that led to low demand and enrolment in education across the main, notably, poor regions, particularly in basic education. These results imply that especially among the poor regions, economic reasons are considered to be the most important factor limiting poor students' and especially, girls' potential to complete their primary (basic), secondary and tertiary

education and that region economic problems impact more negatively on female than on male education. Our results imply that these factors probably interpret the regional disparity in the demand for education across the main regions in Sudan. The major policy implication from our results is that Sudan has the potential to achieve equity and fulfil the second and third MDG on universal access to primary education and gender equality respectively through reduction and elimination of poverty, notably, across the poor regions and poor population in Sudan, and this implies achievement of equity and international commitment to fulfilment of UN MDG in Sudan.

Our results show that the implication and interaction between educational and training policies seem to be effective but limited to only within the largest two mixed and private firms, which appear more committed to implement skill upgrading policies that are consistent with the line of public policies. These two largest mixed and private firms successfully contribute to serve public policies of training and skill upgrading via establishing active human resources development units, recruitment policies and specialized training centres to implement various regular and special internal and external training programmes, especially for national workers. In addition they encourage the use of ICT to upgrade skill levels, offer scholarships and collaborate with universities to absorb young national graduates. These results support our earlier findings in Chap. 5, which indicate a lack of effective interaction between educational and training policies and a lack of incentives for provision of training within private firms. Hence, these findings imply a further duality/discrepancy at the micro level/across small-medium and large private firms.

We next discuss the macro-micro views concerning plans, mechanisms and policies for skill development through enhancing the educational system, provision of training, transfer of knowledge/external schooling effects, effective collaboration between public and private institutions and increasing incentives for private sector investment in education and training in Sudan. Our results show a serious discrepancy and divergence in arranging priorities to implement plans, mechanisms and policies for enhancing skill levels, provision of training and transfer of knowledge at the macro-micro levels. These results are opposite to earlier observations in Chap. 5 concerning the contradicting optimistic-pessimistic macro and micro views concerning upskilling efforts and/or the self-reliance on local skill and the role of both technological upgrading and upskilling in reinforcing it. Therefore, we recommend further efforts be made to enhance the consistency between the macro-micro views and the public-private sectors, particularly in the arrangement of priorities, plans and mechanisms to ensure more consistent, effective and successful policies for skills development.

10.2   Relevance and Contribution of the Research

Most of our findings in this research are consistent with the new growth literature, Arab literature and the Sudanese literature. Compared to the endogenous growth framework, we provide further evidence in support of the endogenous and new

growth literature, in particular with respect to the positive correlation between actual education, experience, its square and wages. Our results in Chap. 7 show positive complementary relationships between technology (ICT), skill and upskilling (ICT training), these findings seem consistent with the theoretical framework in Chap. 3, endogenous growth framework and the stylised facts in the new growth literature concerning the relationships between human capital, technical progress and upskilling. Our findings are broadly consistent with and provide further evidence in support of the findings in the new growth literature concerning the skilled biased technical change theorem. In addition, our results concur both with the general literature that defines both skill and technology in relation to firm characteristics (size and industry), and also the recent literature highlighting the growing effects of new technologies, especially ICT diffusion. Our results in Chap. 8 verify four stylised facts about the importance/impacts of knowledge at the micro and macro levels, and are in line with the recent general findings in the knowledge literature. In particular, the complementary relationship between tacit knowledge and codified sources of knowledge at the macro level and the significant correlations between both tacit knowledge and codified sources of knowledge and output and growth at the micro and macro levels respectively. Tacit knowledge is important not only through its direct effects, but also through its further effects on upskilling and the use of technology (ICT). Our findings about the knowledge components have less significant impacts on output (total sales value) that follow the effects of traditional variables (i.e. labour and capital) are in contrast to the recent results in the knowledge literature, which indicate that knowledge components have more significant impacts on output (total sales value) that exceed the effects of traditional variables (i.e. labour and capital).

On the other hand, we find a positive significant correlation between the use of/total spending on ICT and total profit and value added, but an insignificant correlation between the use of/total spending on ICT and output at the micro/firm level. This result proves our fifth hypothesis in Chap. 1 above and the observations about the insignificant/inconclusive effect of ICT at the macro level in Sudan and the recent literature in the Arab and developing countries. However, our results with respect to ICT should be interpreted more carefully as they probably have two-way causality and may imply a possibility for reversed causality. Mainly because more profit and output would imply more financial capacity that permits more spending on ICT, on the other hand, more spending on ICT implies higher costs and lower profit.

Our findings about the significant correlation between the required education and wages are consistent with the findings in the new growth literature on the importance of job characteristics (skills required) in wages determination.

Compared to the Sudanese literature, we provide new evidence and add to the few recent studies in Sudan that highlight the need for upskilling, and the low skill, low technological level and dependency on foreign technologies. Compared to the Arab and Sudanese literature, our research is important for elaborating and providing a more indepth analysis, not only for assessing Sudanese technology-skill indicators using a more comprehensive set of indicators than often used in the

new growth literature, but also for analysing the causes and consequences of low skills and technology, the relation between them at both the macro and micro levels, and for addressing policy aspects aiming to enhance them. Basically, we identify upskilling as an essential element for building adequate human resources needed for the fulfilment of long run economic growth and sustainable development strategies in Sudan: achieving economic stabilisation; balanced development; economic diversification; reducing poverty; reducing unemployment; restructuring and reducing imbalances in the labour market; creation of adequate and appropriate employment opportunities; enhancing self-reliance on domestic capital and workers; and building institutional reform and technological development. We show that the low skill level is basically attributed to the deficient educational system – due to low quality of education – and high incidence of unskilled workers at the macro and micro levels respectively. The importance of our analysis is the identification of the numerous implications of the interaction between a poor educational system and an excessive share of low educated workers that leads to low skill levels, poor provision of training, skills mismatch, low transfer of knowledge, poor technology indicators and high dependence on foreign technologies. We add to the results of Hassan (2009) and Elamin (2009) regarding the lack of technology policy, technical skills, R&D, technology culture in Sudanese society and the mismatch in the labour market due to deficient educational system and cultural reasons. Using new primary data based on the R&D survey (2010) and firm survey (2010) we provide a new contribution and fill the gap in the Sudanese literature by examining the major factors hindering R&D at the macro and micro levels in Sudan respectively. At the macro level our results from the R&D survey (2010) show that despite the importance of R&D in satisfying the needs for economic development, development of local technologies and adaptation to imported foreign technologies; however, the contribution of R&D seems to be constrained mainly by the lack of finance to cover the high costs of R&D as the main problem, moreover, the lack of human resources (researchers and qualified workers in R&D fields) is also mentioned but is of somewhat less importance. We find that from the policy makers and experts' perspective the main problems hindering R&D at the macro level include: lack of finance from the public sector; lack of management and organisational ability; lack of coordination and weak relationships, networks and consistency and cooperation between universities and higher education institutions on the one side and the productive sector (agriculture, industry, services) on the other side; lack of R&D culture, lack of finance from the private sector; lack of favourable conditions and necessary facilities; lack of awareness and appreciation of the economic values of R&D; and lack of human resources (researchers and qualified workers in R&D fields) respectively. At the micro level our results from the firm survey (2010) show that the lack of local efforts for technology development is basically related to low R&D efforts that are attributed to low skill level, lack of networks systems, fruitful cooperation between universities and firms, lack of resources and lack of social awareness and concern.

We provide basic and new contributions and fill the gap in the Sudanese literature by investigating the significance of the incidence and transfer of knowledge/external schooling effects, the factors hindering and those contributing towards enhancing them at the macro and micro levels in Sudan. We show the significance of tacit and codified sources of knowledge at the micro-macro levels. Unlike the few recent studies of knowledge in the Arab countries, one advantage of our analysis is that we provide a more specific analysis that focuses only on Sudan as a new case in the Arab countries. Different from earlier studies, we provide new empirical investigation of both the importance (impacts) of tacit knowledge at the micro level – see our discussion in Chap. 8 – and the discrepancy in the transfer of knowledge/ external schooling effects at the macro-micro levels – see our discussion in Chap. 5. We show the positive correlation between skill indicators (actual and required education and experience) and between these indicators and wages; the distribution of average wages is significantly correlated with the actual education, experience and its square, and also seem to be sensitive to the required education. We add to the literature in indicating the implications of the poor educational system and the high incidence of unskilled workers in the labour market, particularly the skills mismatch problem at the macro level. A novel element of our research, distinguishing it from the few earlier studies, is that we manage to measure the skills mismatch at both the macro and the micro level/across firms. Our new findings show that at the micro level although occupations are improving with education, schooling requirements are seldom significantly match with the actual/attained schooling, especially within both the high and low skilled worker groups. The gap that appears between the required and actual/attained schooling indicates a mismatch at the micro level, which is notably higher within both high and low skilled workers respectively.

To complement the micro analysis, at the macro level an important contribution in our analysis is that we examine the relationships between the low skill level, skill mismatch, structure of labour market and unemployment in Sudan. One advantage of our analysis is that we explain several stylised facts on labour market using new secondary data on population, employment and unemployment based on the Sudan Central Bureau of Statistics (2010) 'Fifth Sudan Population and Housing Census (2008)'. An interesting element in our analysis is that we explain several stylised facts on the relation between structure of labour market and demographic structure, labour force, participation rates, economic activities, low skill level and high unemployment rate, defined by gender and mode of living in Sudan. Different from the results in the empirical literature in support of Phillips curve on the negative correlation between inflation and unemployment rates, we find positive and significant correlation between unemployment and inflation rates in Sudan during the period 2000–2008. Moreover, different from the analysis in the Sudanese literature we present a more comprehensive analysis of four stylised facts on unemployment problem in Sudan, these include: distinction of several types of unemployment; interpretation of the unemployment problem from two different endogenous and exogenous perspectives due to endogenous and exogenous causes; analysis of high incidence of unemployment among youth population; and high mismatch between educational qualifications – supply – and labour market

requirements – demand. In addition, our analysis is useful from a policy perspective to address the relevant mechanisms and policy issues to reduce unemployment, highlight the role of both public and private labour market institutions and educational policies and the need for incentives, agreement and collaboration between public and private institutions in upgrading skill and reducing unemployment problem in Sudan. The major policy implication from our findings indicate that since the unemployment problem is related to these endogenous and exogenous causes, therefore, policy interventions for reducing unemployment should deal with these endogenous and exogenous causes, notably, improvement of job creation and quality of educational policies and consistency between educational qualifications (output) and labour market requirements. Another major policy implication from our result on the significant positive correlation between increase in unemployment and inflation rates (2000–2008), implies that macroeconomic policies aimed at targeting reducing inflation rates would also contribute to reduce unemployment rates in Sudan.

Compared to the Sudanese literature, a new element in our analysis is that we show that the low skill levels may contribute to productivity decline across firms; we illustrate considerable variation in the value and trend of labour productivity (total output/labour ratio) in physical terms, in particular, considerable decline in labour productivity (output/labour ratio) for numerous firms over the period 2005–2008. In addition we show that the low skill levels may contribute to the trend of decline of industrial performance indicators across firms over the period 2005–2008, which we measure by three different sets of economic and productivity indicators, activity indicators and profitability indicators. Compared to the Sudanese literature, a new and novel element in our analysis is that we illustrate and assess the value and trend of industrial performance indicators across firms over the period 2005–2008 that we measure by three different sets of economic and productivity indicators, activity indicators and profitability indicators. We assess the industrial performance by the first set of economic indicators including the degree of industrialisation indicator, capital intensity level indicators and a set of productivity indicators such as labour productivity, capital productivity, fixed capital productivity, wage productivity and raw materials productivity indicators. In addition, we assess the industrial performance by the second set of activity indicators including both capital and fixed capital turnover ratios and the third set of profitability indicators including the rate of return on labour or profit/labour ratio, the rate of return on capital or profit/capital ratio and profit margin or profit/sales ratio. Our results imply that in most cases an increase in skill level (share of high skill in total employment), firm size and industry most probably leads to an improvement in most of industrial performance indicators.

Compared to the Sudanese literature, we provide a new contribution and we improve the understanding by explaining the important potential contribution of the industrial sector in enhancing economic development in Sudan from the perspective of the industrial firms based on our results from the firm survey (2010). Our results from the firm survey (2010) are consistent with the findings in the developing country and Sudanese literature that indicate several problems of industrialisation

in Sudan and similar to those in the typically developing countries. Different from the studies in the Sudanese literature which provide somewhat general overview concerning the problems of industrialisation in Sudan, an interesting and novel element in our analysis is that our findings is based on recent micro primary data based on the firm survey (2010) and the follow-up interviews with firms managers and we present new and a more elaborate interpretation of the main problems of industrialisation in Sudan from the perspective of the different industrial firms considering the opinions of a more diversified sample of industrial firms, defined by industry and size. In addition we provide a new contribution since our findings from the firm survey (2010) support our argument that the low skill levels may contribute to the declining of labour productivity and other industrial performance indicators including economic, productivity, activity and profitability indicators across firms. We provide a new contribution since our results recognise that improving skill level is an important factor for facilitating improvement of labour productivity and other industrial performance indicators, so upskilling or improving skill level and adequate availability of skill and trained labour force are amongst the important factors facilitating improvement of industrial firms performance and contribution towards economic development in Sudan.

Our findings concerning the channels of technology transfer and the wide variation between the level of technology transfer in the different industrial scales and activities/sectors are not only consistent with some findings in the Arab literature (e.g. Nour 2005) but also go beyond the other findings in the Arab literature (e.g. Elsabaa 1997). This is because we identify wide variations in the preferred channels of technology transfer that include not only joint ventures and foreign industrial projects, but also strategic alliances, hiring foreign skill/technologically advanced workers and consultants, technology licensing and FDI. We show that across firms not only the level of technology use and channels of transfer are determined by firm size and industry, but also skill and technology indicators (the use of ICT, R&D, patent, product and process innovations) and most of the industrial performance indicators are significantly defined by firm characteristics, i.e. size and industry. These results are consistent with the general literature, which illustrates that both large size firms and high intensive/active industry (e.g. chemical) are more intensive in terms of the use of technology and skills. However, one should also expect that these results might imply a possibility for reversed causality, mainly because R&D is a fixed cost that requires high financial capacity, which is most likely to be stronger amongst large size firms.

We add to the very few studies in the Arab literature concerning the positive impacts the technology transfer brings to output/production (Nour 2005; Elsabaa 1997) and the negative impact the use of technology induces in the demand for unskilled workers/labour saving effect (Nour 2005; Haan 1999). We provide a more elaborate analysis, relying not only on the qualitative effects of the use of technologies, particularly ICT diffusion on the demand for labour and the effects of increasing use of technologies on product and process innovations, but also on the quantitative effects of ICT on output and profit. These finding together with our results concerning the surprising contradicting views relating to the transfer

of knowledge and impact of ICT are all seem to be consistent with the results in the Arab literature (e.g. Nour 2005).

Our new results from Chap. 9 is consistent with the results in the Arab literature since we show that the implication and interaction between educational and training policies seem to be effective but limited to only within the largest two mixed and private firms, which appear more committed to implement skill upgrading policies that are consistent with the line of public policies. These two largest mixed and private firms successfully contribute to serve public policies of training and skill upgrading via establishing active human resources development units, recruitment policies and specialized training centres to implement various regular and special internal and external training programmes, especially for national workers. In addition they encourage the use of ICT to upgrade skill levels, offer scholarships and collaborate with universities to absorb young national graduates. These results support our earlier findings in Chap. 5, which indicate a lack of effective interaction between educational and training policies and a lack of incentives for provision of training within private firms. Hence, these findings imply a further duality/discrepancy at the micro level/across small-medium and large private firms. Therefore, we observe that, in contrast to medium and small size private firms, large mixed and private firms (Kenana Sugar Company (KSC) and DAL Group) in Sudan have successfully contributed to serve the public policies for enhancing training and skill upgrading, especially amongst national workers. However, it is less clear whether these two large mixed and private firms (KSC and DAL) induce positive effects on upskilling workers in private firms. In our view, the interpretation of the serious discrepancy between these two large mixed and private firms and other firms can be attributed to presence of high resources, support and incentives within these two firms, which are probably lacking within other private firms.

Our findings are consistent with the results of the Sudanese and Arab literature concerning the poor quality of education and the Sudanese literature concerning the low commitment to the standardised international adequacy, equity and efficiency criterion related to educational policies. Different from the Sudanese and Arab literature, we provide a more elaborate analysis and new evidences concerning the serious problem of the poor quality of education, and an interesting element in our analysis is that our results are more comprehensive and show the low commitment to the standardised international adequacy and poor equity and efficiency criterion related to the supply and demand sides of educational policies in Sudan. We explain that the low commitment to the standardised international adequacy, equity and efficiency criterion is obvious not only from the supply side as measured by low rates of trained teachers and overcrowded classrooms as indicated by students enrolment per education institutions, but also holds from the demand side as measured by low rates of enrolment and attendance, high rates of dropout, high rates of repetition, weak rates of success in the final exams in the basic and secondary, mainly, technical education. We provide new a contribution to the Sudanese literature by explaining the regional inequality and disparity in the supply and demand sides of education, notably we explain that it is probably plausible to interpret the observed regional disparity in the share in demand and enrolment

in education due to demographic reason (as measured by the share in total population), economic reasons (as measured by per capita income and poverty rate) and other reasons (as measured by the degree of urbanisation) across the main regions in Sudan. Notably, our results imply that the increase in the incidence of high poverty rate and low per capita income seem to be the most important factors determining, limiting or leading to low demand and enrolment, notably, in basic education, especially for females across the main regions in Sudan. Our results imply that these factors probably interpret the regional disparity in the demand for education across the main regions in Sudan. The major policy implication from our findings is that Sudan has the potential to achieve equity and fulfil the second and third MDG on universal access to primary education and gender equality respectively through reduction and elimination of poverty, notably, across the poor regions and poor population in Sudan, and this implies achievement of equity and international commitment to the fulfilment of the UN MDG in Sudan.

10.3   Policy Recommendations

The major policy recommendation from this research is that skill development policies can be enhanced by making improvements to the educational and training systems and enhancing the transfer of knowledge/external schooling effects. As for improving of education, the major policy recommendations include the improvement in the quality of teachers or mentors, infrastructure, planning for educational needs, the internal efficiency/quality of basic, secondary, technical and tertiary education, encouraging the systems of modernisation and dynamism. In addition, measures should be undertaken to enhance the linkages (networks) between universities, colleges, technical and training institutes, monitor educational needs on a regular basis, encourage the system of flexibility of educational institutions and increase the harmony/consistency between educational output and market needs. In addition, further measures include: increasing incentives for enrolment and spending on education by both public and private sectors particularly in tertiary and technical education; changing the attitudes of educated economically active population; improvement of regulations/laws to legitimise sufficient duration of compulsory education; and decentralisation of decision-making.

Concerning the improvement of training, the major policy recommendations include enhancing the educational qualifications of workers, availability of training materials and equipment, planning and regular/adequate assessment and monitoring of training programmes to fit the changing technical and skill needs. Further recommendations include increasing the appreciation of or information on the benefits of training, improving the quality and availability of trainers and mentors, enhancing availability of finance to cover training costs. In addition, there should be measures aimed at encouraging specialised training institutions, the interactions between training institutions and firms, enhancing the full appropriability of return from investment in training, enhancing the system of training certification of skill

acquired, increasing the participation of private training institutions and decentralisation of training provision. With respect to improvement of the transfer of knowledge, the major policy recommendations include an improvement of the quality of education and training and the qualifications of both skilled and unskilled workers to permit the positive effects of skilled workers on unskilled workers. In addition, there are recommendations that aim at the improvement of firms conditions to encourage the external effects, sponsoring educational scholarships, increasing the interaction to market needs through increasing the information about future educational, training and skill needs, especially in the productive sectors and their demand for graduate students. The policy recommendations also aim at increasing awareness about future value of investments in education and training, enhancing a system of certification of skill acquired, providing adequate incentives for trainers and minimisation of education, learning and training costs.

Since the skills problem is partially attributed to high presence of unskilled workers, skill upgrading requires both a reduction in numbers and an upgrading of unskilled workers. There is much to be learned from the successful stories in the rapidly advanced countries, in particular, the experiences of skill upgrading in Singapore and Korea (see our results in Chap. 3).

In view of the complementary relationship between skills, skill upgrading and technological progress (see our discussion in Chaps. 3 and 7) the development of education, training, transfer of knowledge and skill levels may have further positive implications on the development of local technologies. Accordingly, the promotion of local technologies depends on skill upgrading, promotion of R&D activities and the enhancement of networks systems, collaboration between universities, firms, public and private sectors and implementation of an explicit technology policy.

Finally, our results show that the main suggestions to improve R&D includes: availability of sufficient finance from public sector; availability of sufficient finance from private sector; offering incentives and motivation and facilitate availability of sufficient human resources (researchers and qualified workers in R&D fields); improvement of management and organisational ability and coordination; improvement and strengthening the relationships, networks, consistency and cooperation between universities and higher education institutions on the one side and the productive sector (agriculture, industry, services) on the other side; and improvement of awareness and appreciation of the economic values of R&D. This is followed by creation of more favourable conditions and offering all facilities and improvement of R&D culture. Hence, our analysis indicates that in order to improve S&T performance, Sudan needs to invest heavily in both financial and human resources and to learn from the lessons of the advanced and developing S&T nations. Furthermore, investment in science and technology can be more effective if it is made according to targeted and well-defined comprehensive national plans for improvement of economic performance covering all productive sectors (agriculture, industry, and services) and adopting new policies for partnership with the private sector. Sudan needs to form a body to formulate a policy on manpower resources for S&T, suggest measures to minimise brain-drain impacts, to continue building well-developed S&T infrastructure, mainly, sufficient number of highly

qualified university and R&D personnel to put Sudan in a good position in terms of globally competing in S&T. So far Sudan does not possess all the human and financial resources necessary to promote S&T; however, Sudan could have a wider range of capabilities to promote S&T if it pooled and integrated its resources, restructuring the economic system, encouraging the private sector and implementing effective S&T cooperation with regional, global and international S&T institutions, which will most likely enhance S&T development and hence long-term harmonious development in Sudan.

Our findings from the firm survey imply several recommendations for the development of the industrial sectors in Sudan. We recommend the government to seriously address the problems hindering accelerating industrial development. In addition, others recommendations include facilitating the use of new and advanced technologies, supporting stimulating environment to encourage investment in industrial sector, improving managerial and organisational capability and improving regulations and laws related to improving adequate supportive work conditions for stability of workers in employment and reducing potential movement of workers to other work after short period by increasing sufficient wages for workers and their families. In addition, we recommend the government support domestic industry by implementing policies for protecting domestic industry, preventing dumping of the local market and preventing presence of intermediary and middlemen in industry. Moreover, we recommend the government to encourage industrial sector by reducing prices of energy, electricity and water, providing raw material locally, facilitating clearance and reduced customs duties for imported raw materials and removing taxation, levies, customs and fees imposed on industrial firms. Furthermore, we recommend the government to support R&D activities and cooperation between industrial firms and universities in Sudan. In addition we recommend the government support provision of training to Sudanese trainers and trainees by reducing training costs, rehabilitation and increasing specialised training centres, focusing on practical rather than theoretical training, increasing vocational and management training, introducing modern training methods and linking human resources development strategies with economic development strategies. In addition we recommend the industrial firm owners and managers to support a major change from adopting the current short-sighted commercial perspective that aims only to make high profits to recover expenses on investment, to adopting a new alternative far-sighted entrepreneurial perspective to focus on qualitative development of the industrial sector by enhancing R&D, training and skill upgrading in industrial firms. Furthermore, we recommend the government encourage national capital to invest in human resource development, and use of modern methods of production and development of technology by creating stimulating environments that beg for industrial development in Sudan. Moreover, we recommend the government encourage industry by provision of infrastructures, modern machinery, qualified administrative staff, and financial capital by offering sufficient loans, funding through banks and encouraging foreign investment, in addition to improvement of internal and external marketing opportunities and prevention of bureaucratic and slow procedures. In addition, we recommend the

government enhance relationships between industrial and agricultural sectors and to increase support for manufacturing industries such as textiles, leather and animal products because of their comparative advantages and direct effect on the economy and employment. In addition, we recommend the government improve the culture of cooperation and coordination between industrial firms, the Ministry of Industry and other ministries, to encourage implementation of economic policies to prevent duality of decisions or resolutions, prevent discrimination and confirm unification and equal treatment for workers in public and private sectors. Finally, we recommend the government adopts a far-sighted vision, implements a more consistent industrial development strategy and encourages learning from the successful stories in the East Asian industrial renaissance.

Our findings from the macro survey imply several recommendations for skill development in Sudan. We recommend the government seriously review policies and planning for development and modernisation of education and training systems at all levels, to increase spending on education and training, encourage participation of private institutions in enhancing education and training, improve appropriate curricula for each education level to fit with capacity of students and their families and encourage free education. We recommend the government to enhance the culture and awareness of the importance of skills development among employees and encouraging commitment of public and private employers to training and skill development strategies according to specialisation of workers. Furthermore, we recommend the government improve provision of training for trainers by facilitating internal and external training in internal and external training institutions and to improve coordination for training by supporting and providing adequate resources and facilities to the National Council for Training to coordinate and organise public and private training activities and institution. In addition, we recommend the government support expansion of vocational and technical training and continuing specialised training internally and externally, taking into account labour market requirements. Moreover, we recommend the government adequately incorporate skill development strategies in the current national strategic plan and increase commitment of training units of central ministries to skill upgrading strategies by supporting specialised investment in education and training in all related institutions. Furthermore, we recommend identification of training needs on three levels; first at the enterprise-level, for example, training for all employees on a new system of organisation, second at the job level, for example, specification of the requirements of the job level and necessary skills of the job and third, at the individual level, for example, determining the level of the individual needs of the training compared with the requirements of the job undertaken by the individual. Moreover, we recommend encouraging the transfer of knowledge by supporting and directing the culture of the community towards the interest in education and training and learning from the experience of other countries that promoted skill, education, training and human resources.

10.4 Direction for Future Research

We plan to utilise and extend the major findings of this study for future empirical research to improve understanding of the causes and consequences of low skill and technological level in other Arab countries with similar circumstances. It is hoped that our future research makes reference/would be relevant to more than one country and the results could be generalised and extended to be of value, use and benefit to other developing countries. It is also hoped that the results will generate some useful insights for international comparisons across developing countries and contribute to enhancing the accumulation of human capital, external schooling effects/transfer of knowledge, upskilling, technological capacity, social welfare and economic development in the developing countries.

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