# Accumulation and Allocation of the Investment in Human Capital for Manufacturing Growth: Evidence from Manufacturing Industries in Selected African Countries

by

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## Abstract

Both the accumulation of human capital and its allocation are important to spur manufacturing growth. We employed Romer's endogenous growth model to determine the impacts of human capital accumulation and allocation on value-added per worker in manufacturing in Ethiopia, Kenya, and Mauritius. These countries offered useful comparisons because of the differences in the structure and dynamic of their manufacturing industries. The model differentiated between human capital allocated to the production and non-production (such as research and management) workers. For each country, we employed a panel of annual data available for the period 1969-97 and nine two-digit level ISIC code industries. Results showed that although the human capital allocated to production was positively associated with value-added per worker, it was the human capital accumulated and allocated to the non-production workers that most affected growth in manufacturing value added for these countries.

Keywords: manufacturing, human capital, growth, value-added, Africa.

## Introduction

Past attempts to promote the development of manufacturing industries in many countries in Sub-Sahara Africa have fallen short of the desire to increase employment and income through value-added creation. It follows that manufacturing in these countries has remained largely uncompetitive and weak. In 2004, for instance, the real per capita manufacturing value added in Sub-Saharan Africa was about 61 USD, which is only about one-eightieth of that in high income OECD countries (World Bank). A well-known example of the failed attempt to retain value added through manufacturing in some African countries is the import substitution strategy from the early 1960s to mid-1980s; this strategy consisted of building physical capital-intensive manufacturing industries to produce formerly imported final goods and protecting such industry in the domestic market (Balassa 1970, 1978; Stewart 1991; Bruton, 1998). The import substitution strategy was costly, caused current account deficits and overvaluation of the local currencies, and failed to create sustainable growth in employment and income (Bruton 1998).[1] More recently, manufacturers in many countries in Africa have pinned their hopes on greater market access and fairer trade policies, but the lack of competitiveness of their products in both domestic and international markets has hampered manufacturing growth severely.

One view is that the failed attempts to promote growth in manufacturing shared at least the common roots of an overemphasis on the investments in physical capital and market access combined with a neglect of human capital development. The history of manufacturing in industrialized countries seems to vindicate such a

[1] Ridell (1990) asserted, however, that in many African countries import substitution did not fail since it was not even tried.

view in that investment in human capital—the source of production and managerial skills and high-quality research—has been an indispensable input leading to these countries' high manufacturing productivity and growth (e.g., Baumol, 1986; Broadberry, 1993; Ochoa, 1996; Cörvers and de Grip, 1997).[2] Contrastingly, in many Sub-Saharan African countries, the human capital available to the manufacturing industries has always been scarce (e.g., McMahon, 1987; Tybout, 2000; Oyelaran-Oyeyinka, Barclay 2004), and the investment in local human capital for manufacturing growth has remained weak.

In addition to the weak human capital investment, an important factor that can be linked to the lack of progress of manufacturing was the relative allocation of investment resources between production workers (those engaged directly in production) and non-production workers (those not engaged directly in production). This issue is crucial in the case of Sub-Saharan African where investment resources are scarce; the problem led to a long-standing debate. Some authors like Wood (1994) argue that efforts should target mostly the general education and training of production workers, given the low level of skill of the African workforce; others (e.g., Bigsten et al., 2000; Fafchamps and Söderbom, 2006) more recently contend that the priority should be on issues such as labor management or research. There is no simple answer, and more investigation on this allocation of human capital investment is needed.

Policy makers and development partners have acknowledged that the future of development and increase in value added in all sectors lies in investment in human capital (Africa Development Group 2014). However, compelling evidence for the importance of the accumulation and allocation of human capital in African

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[2] Studies (Griliches 1969; Duffy, Papageorgiou and Perez-Sebastian, 2004) have indicated the importance of the 'capital-skill' complementarity for technological progress and growth.

manufacturing from the literature is lacking.[3] More important, efficient ways to allocate efficiently the investment resources between production and non-production workers are often overlooked. Such a knowledge gap may have delayed persuasion of decision makers to increase human capital investment to promote manufacturing growth. This paper aims to contribute to filling this gap.

Our objective is to estimate the impact of the human capital accumulation and allocation on manufacturing output and value added in three African countries: Ethiopia, Kenya, and Mauritius. The observation period covers the years from 1969 to 1997, capturing the major changes in manufacturing in these countries, especially from the era of the nationalization and import-substitution in the 70s to the time of economic slumps and reforms in 80s and late 90s. These three African countries have had different manufacturing structures and dynamics and offer a useful basis for comparison in explaining the role of human capital accumulation for manufacturing growth in Sub-Saharan Africa. Table 1 shows that the ‘Food, Beverage, and Tobacco’ industry in Ethiopia and Kenya and the ‘Textile’ industry in Mauritius were the major contributors of manufacturing value added. Unsurprisingly, as table 2 shows, manufacturing exports in these countries imitated such a distribution. These production and export structures of manufactured goods have remained in sharp contrast with developed countries’ manufacturing production and exports, which are dominated by physical- and human- capital intensive goods (Katrak, 1973; Bassanini, Scarpetta, and Visco, 2000). The paces of manufacturing growth differ significantly among the three countries, especially since the early 80s, with the textile-dominated manufacturing in Mauritius growing faster than the food and beverage-dominated manufacturing in Kenya and Ethiopia. These countries also differ in the level of

[3] See Stewart (1991); Bigsten et al. (1998); and Soderbom and Teal (2000) show .

contribution of manufacturing industries to the economy. For the period 1990-95, for instance, the share of manufacturing value-added of the total Gross Domestic Product is 21 percent for Mauritius compared with 11 and 5 percent for Kenya and Ethiopia, respectively (World Bank).

(Table 1 here)

(Table 2 here)

This paper contributes to the literature on human capital in at least two main ways. First, it presents much need evidence on the importance of human capital in African manufacturing growth where data and studies have been scarce. Second, it provides a macroeconomic approach to the study of manufacturing growth that emphasizes not just on the accumulation of human capital, but more important the allocation of human capital between production and non-production workers; these are departures from and improvements on past work that mostly focused on labor productivity at the firm level or on human capital accumulation only. The findings herein suggest important implications for ways that investment in human capital can help manufacturing industries in Sub-Saharan Africa grow steadily.

## Theoretical Model

Following the basic endogenous growth model by Romer (1986, 1990), we assume that the manufacturing industry has two sectors: the production sector (e.g. basic tasks such as handling machines and cleaning) and the research or non-production sector (e.g., research and management). The total endowment in human capital $H$ is allocated between these two sectors; that is, $H = H_A + H_Y$, where $H_A$ represents human capital going into the research sector, and $H_Y$ represents human capital going into the production sector.

The research sector produces knowledge using human capital; the growth rate of knowledge production is assumed to be proportional to the amount of human capital devoted to research according to the expression,

$$\dot{A}/A = \delta . H_A, \tag{1}$$

where $A$ is the stock level of knowledge, $\delta$ is a constant productivity parameter, and the dot (.) notation represents the instantaneous change for the time derivative of a variable ($\dot{A} = dA/dt$). The stock level of knowledge, $A$, is assumed to affect the range of durable inputs produced and invented in the research sector: the higher the stock of knowledge, the more types of durable inputs produced. This assumption also implies that each durable input is only produced by the research sector.

Specifically following Romer (1990), we express the final output at the industry level as a function of human capital used in production, the amount of labor, and a total list of physical capital. The total list of physical capital, $n$, is partitioned into $n_i$ distinct lists corresponding to each durable input of type $i$ ($i$ =1, 2, 3, …, $A$). These durable inputs contribute to making up the manufactured final good. The $n_i$ can be thought of as numbers of ingredients (or primary inputs) that make up a single durable input *i*. Using the continuous notation of a summation, the total list of physical capital is $n = \int_0^A n_i di$, and the production function is written as

$$Y = H_y{}^{\alpha} L^{\beta} \int_0^A n_i{}^{1-\alpha-\beta} di, \qquad (2)$$

where *Y* is the final good output and *L* is amount of labor. The terms $\alpha$ and $\beta$ are positive parameters that represent output elasticity with respect to human capital in the production sector and with respect to labor. The restriction on the parameters is that $\alpha + \beta < 1$, in order to keep the exponent in the list of durable inputs positive.

One characteristic of Romer's specification in (2) is that the durable inputs are perfect substitutes: an additional dollar of one durable input does not affect the marginal productivity of any other durable input. If each durable input has the same list size $\bar{n}$ (that is, the durable inputs are "symmetric"), and if we take into account that state of knowledge *A* also represents the number (or the range) of durable inputs produced, the integral term in (2) can be written as:

$$\int_0^{\infty} n_i{}^{1-\alpha-\beta} di = A\bar{n}^{1-\alpha-\beta}, \qquad (3)$$

where $\bar{n}$ is a fixed number of inputs (also called intermediate goods) for every durable input. To get an accounting measure of capital, it is assumed that $\eta$ units of capital are used to produce one unit of each ingredient of the durable input. Then the total amount of capital, *K*, entering the production of final output can be written as: [4]

$$K = \eta.\ \bar{n}\ A. \qquad (4)$$

[4] For example, in the ice cream industry, assume that "durable" inputs are *i* = milk, sugar, and flavor. In this case, A (the number of durable inputs) = 3. Consider one of the durable inputs, say, flavor. If the flavor is made of only two ingredients (say, solvent and pure extract), then $n_{\text{flavor}} = 2$. Assume also that $\eta$ = 1 unit of solvent and $\eta$ = 1 unit of pure extract are combined to make up one unit of flavor. Under the assumption that $n_i = 2$ and $\eta = 1$ for the other durable inputs as well, the total amount of capital is $K = 1 \times 2 \times 3 = 6$, following equation (4).

Solving for $\bar{n}$ in (4), substituting into equation (3), and then substituting again into equation (2), the production function can be rewritten as:

$$Y = H_y^{\alpha} L^{\beta} A(K / \eta.A)^{1-\alpha-\beta}. \tag{5a}$$

After rearranging terms, the general expression of the industry output from (5a) becomes

$$Y = A^{\alpha+\beta} \eta^{\alpha+\beta-1} H_y{}^{\alpha} L^{\beta} K^{1-\alpha-\beta}. \tag{5b}$$

The role of human capital is important under the Romer model because the human capital going to research (the non-production sector), $H_A$, produces knowledge (see equation (1)) in private firms, and it is this produced knowledge that drives the growth of output. It can be shown that the balanced per capita growth rate of output equals the growth level of knowledge $A$ and hence depends on the level of human capital devoted to research. For instance, under such a balanced growth-path an increase in subsidy of the investment on physical capital without an increase in human capital devoted to research can be counterproductive. We now use equation (5b) to test the effect of such a hypothetical effort on human capital accumulation and allocation. [5]

[5] The Romer model resembles some other growth models (e.g., Solow, 1956; Lucas, 1988; and Mankiw, Romer, and Weil, 1992) in that it specifies that (i) technological change is the source of output growth and that (ii) technology is a non-rival input in the production function. Also see Aghion and Howitt (1992; 1998) and Barro and Sala-i-Martin (1992; 1995) for ample details. One sees, for instance, that the production function derived in (5b) exhibits constant return to scale (CRS) if one assumes that $H_y$, $L$, and $K$ are the only main inputs; in that aspect, it is comparable to the Solow-Swan growth accounting model (Solow, 1956) and matches the augmented Solow model (Mankiw, Romer, and Weil, 1992). The main difference between the Romer model and the other models (especially endogenous growth models) lies in the endogeneity of the level of knowledge $A$ in the production function. In the Romer model, unlike the augmented Solow model for instance, the level of knowledge $A$ is produced under an Increasing Return to Scale technology by private profit-maximizing firms within the industry.

**Empirical Models**

Using equations (1) and (5b), we develop an empirical model to estimate particularly the impact of human capital on output and value-added in manufacturing. Expressing (5b) in terms of output per worker and then taking the logarithm of both sides of the equation leads to the equivalent formulation of output per worker:

$$\log y = (\alpha+\beta)\log A + (\alpha+\beta-1)\log\eta + \alpha\log h_y + (1-\alpha-\beta)\log k$$

where the lower letter cases $y$, $h_y$ and $k$ represent respectively output (or value added), human capital, and physical capital, all per worker. In addition, $\eta$, the amount of capital used to produce durable inputs, can be split into time- and manufacturing-specific dummy variables, as policies (such as physical input subsidy) may differ by industry over time. Taking into considerations the above remarks and adding a stochastic term and industry $i$ and time $t$ subscripts yields the following econometric formulation in terms of output per worker:

$$\log y_{it} = \gamma_A \log A_{it} + \gamma_t t + \gamma_i + \gamma_h \log h_{yit} + \gamma_k \log k_{it} + \varepsilon_{yit}\,, \tag{5c}$$

where $A$ is the level of knowledge and subscripts $i$ and $t$ indicate the type of manufacturing and time period. The $\gamma$'s are parameters; the $\gamma_t$ and $\gamma_i$ are the time trend coefficient and manufacturing dummy, respectively: they capture the amount of capital employed to produce durable inputs.

After taking the integral on both sides of (1), an equivalent formulation of the level of knowledge is $\log A = (\delta.\Delta T).\ H_A$, where $\Delta T$ is an arbitrary and finite positive number measuring the time needed to produce knowledge in the research sector. The log-level of knowledge can then be written as:

$$\log A_{it} = a + \lambda_{HAt}\Delta T(H_{Ait}) + \varepsilon_{Ait}\ , \tag{1a}$$

where $a$ is a constant, $H_A$ is the amount of human capital going to research, $\lambda$ is a parameter, and $\varepsilon_{Ait}$ is the error term.

Under the endogenous growth model, i.e. where the level of knowledge *A* is determined endogenously, the parameters of the equations (5c) and (1a) are determined simultaneously and log*y* and log*A* are the endogenous variables. There is however no available data to track the exact increase in stock of knowledge per industry category for the three African countries; we solved this data problem by estimating only the reduced-form parameters of the equation of interest. The reduced-form equation for estimation is thus obtained by substituting the term $\log A_{it}$ in (5b) for (1a) and is written as:

$$\log y_{it} = \theta_0 + \theta_t t + \theta_i + \theta_{HAt}(H_{Ait}) + \theta_{hy} \log h_{yit} + \theta_k \log k_{it} + \varepsilon_{yAit}, \tag{6}$$

where the $\theta$'s are the parameters to be estimated. We note here that, in (6), both the industry dummy-variable $\theta_i$ and time trend coefficient $\theta_t$ capture the effects of changes, including voluntary policy changes, in levels of physical capital specific to a manufacturing category and over time.

**Data and Estimation**

We estimated the parameters of the Romer model expressed in (6) to determine the effects of human capital on output among various industries in Ethiopia, Kenya, and Mauritius. For each country, we employed a panel of annual data with slightly different time coverage: 1969-97 for Ethiopia, 1970-97 for Kenya, and 1970-96 for Mauritius. In Kenya and Mauritius, nine manufacturing industries at the two-digit level (ISIC codes) constitute the cross sectional units of the panel data. Ethiopia's data set has only eight industries in the two-digit ISIC codes; the "other industry" category (ISIC 39) did not exist for Ethiopia because industries in this category had been merged into the first eight categories. The data for manufacturing output, value-added, capital stock, labor, and wages are mainly from the International

Yearbooks of Industrial Statistics of the United Nations Industrial Development Organization (UNIDO), the Labor Statistics of the International Labor Organization of the United Nations, and local government publications (Central Statistics Office of the Republic of Mauritius; Kenya National Bureau of Statistics). The monetary values are kept in local currency units.

*Key variables*

As proposed in Jorgenson and Fraumeni (1996), industry output can be represented in a two-stage expression. First, value-added is a function of physical capital, human capital, and labor. In the second stage, output is a function of value-added and other intermediate goods. Because the interest here is mainly in examining the importance of human capital, this study focuses specifically on the first stage and takes annual value-added per worker by industry as the dependent variable. Following the UNIDO data, value-added in this study is the output value subtracted from the values of all purchased materials (raw material including packages).

Because of the data limitation, we use wage differential to represent the human capital variables. The use of wage differential as the proxy for human capital has been discussed in various studies (e.g., Branson, and Monoyios, 1977; Stern and Maskus, 1981; Bound and Johnson, 1992; Bowen, Hollander, and Viaene, 1998; and Jones, 2001). For the Romer model, we first determine the numbers of production workers $L_y$ and of non-production workers (technicians, researchers, and managers) $L_a$ using the relation that the total wage bill $W$ is the sum of wage bills paid to production and to non-production workers: $W=L_y.\omega_y+L_a.\omega_a$ , where the $\omega$'s are known wages rates and the subscripts $y$ and $a$ indicate production and non-production workers, respectively. The amount of human capital going to production is then proxied as the product of the number of production workers and the difference between the production workers' wage rate and the lowest occupational wage in the country (often the wage in agriculture or in the wearing and apparel industry). Likewise, the amount of human capital going to research (including management, planning, and supervisory tasks) is proxied as the product of the number of non-production workers and the difference between wage of non-production workers and the lowest occupational wage in the country.

**Results and Interpretations**

One of the industry dummies was dropped during the estimation to avoid collinearity problems. Preliminary testing of the series' stationarity indicated that first order autoregressive error terms have to be specified in each cross-sectional unit for all three countries. The presence of contemporaneous correlation of the error terms among the nine categories of industries was also detected; one possible reason is that the manufacturers draw inputs from the same input markets. Moreover, the heteroskedasticity problem was found; this is not surprising because of the different sizes of the industries. Given such conditions, we used Parks' method to estimate parameters in equation (6). [6] Parks' method is a two-stage Generalized Least Square, which corrects for autocorrelation and heteroskedasticity. Parks showed that the parameter estimates are consistent and asymptotically normally distributed. Dummies for the time periods were also introduced after checking for structural change. Concerned about the endogeneity that may arise from a possible two-way link between the human capital proxies and value-added per worker, we ran Hausman tests that found no significant endogeneity problem.

[6]The Parks' method (Parks, 1967) corrects for heteroskedasticity and autocorrelation at the same time. It is a two-step GLS procedure in which during the first step the variance-covariance of errors is estimated by variable transformation using the first order autoregression coefficient, and during the second step the estimated variance covariance of errors is used for parameter estimation.

The results for the estimation of parameters of the Romer model are summarized in Table 3. The negative time dummies indicate falling trends in value-added per worker after the structural break for Ethiopia and Kenya. By contrast, Mauritius has enjoyed an overall increasing trend in value-added per worker over time.

(Insert Table 3, here)

The impact of individual industry characteristics capturing the physical capital investment varies across countries. It is important first to note that the values of these industry dummies are relative to the manufacturing industry dropped during the estimation. The industry dummies are often statistically significant for Ethiopia and Kenya; this result confirms that, across categories of the manufacturing industry, the effects of the investment in physical capital on value-added per worker differed significantly from the 'Textile' and 'Wood product' industries in Ethiopia and Kenya, respectively. The highest impacts appear to be on the 'Food, Beverage, and Tobacco' and 'Chemicals, Refineries' industries. For Mauritius, the industry coefficients are only significant for the 'Textile, Wearing apparel, Footwear' and 'Other' industries. This is not surprising as these two industries happened to have had the lowest value-added per worker across all categories.

The parameters on the physical capital stock are all positive and statistically significant, indicating that the growth of value-added per worker is positively related to the growth of investment in physical capital. The coefficient values, however, differ across countries: value-added per worker in Ethiopia is least responsive to an increase in capital stock whereas that of Mauritius is most responsive. Such a result is not surprising as the relatively strong manufacturing industries in Mauritius have had better access to physical and financial capital than those of Kenya or Ethiopia. It is also consistent with Mauritius's favorable ratings in investment risk assessments, leading to large inflow of financial investments and high returns on these investments. Undoubtedly the high investment returns benefited also its manufacturing industry, as the findings suggest.

More important, for all three countries the values on the coefficients for the human capital going to the research or non-production sector (research and management) of the manufacturing industries are statistically significant with the expected positive sign. As the human capital for that sector is counted in 100 000 local currency units (LCU), the result indicates that investment in human capital to research sector producing a total earning of one million LCU per year would have increased manufacturing value-added per worker by 22 percent in Ethiopia, 1.2 percent in Kenya, and 1.4 percent in Mauritius. The large differences among these numbers can be partly explained by the differences in exchange rates to the dollars in these countries: Ethiopia's currency unit, the *birr*, is worth more to the dollar than both the Kenya's *shilling* and Mauritius's *rupee*. So we use instead the 1990 exchange rates to eliminate the exchange rate bias and find that each million dollars of total wage earning from a human capital investment in non-production workers (to do research and improve management) for each country would have increased manufacturing value-added per worker and per year by 1.8 percent in Ethiopia, 1 percent in Kenya and 0.7 percent in Mauritius. The relatively high response in Ethiopia stems partly from its relatively small manufacturing value-added on both total and per worker bases; this could make the percentage increase appear much higher. In 1995, for instance, Ethiopia's total manufacturing value-added was 350 million USD, which was about one-half of that of Mauritius and less than one-third of

Kenya's. On a per worker basis it was 4212 USD, which at that time amounted to about three-fourth of that of Kenya and half of that of Mauritius. Still the result indicates high returns in human capital investment allocated to research and management sector; each million dollar of earning from an investment in human capital to the research and management sector yields 6.5, 4.7, and 4.4 millions USD for Ethiopia, Kenya, and Mauritius respectively.

These returns from investments in human capital for the non-production sector are far higher than the returns from the investment in human capital going to production, for which the coefficients are barely significant or even statistically close to zero, except in the case of Ethiopia. But even for Ethiopia, the one percent increase in earning from an investment in human capital of a production worker would produce less than one-tenth of a percentage increase in value-added per worker; using 1995 figures, a one million dollar return from an investment to improve the skills of production workers would yield about 1.4 million USD increase in value-added, which is only about one-fifth of the 6.5 million USD return on the human capital investment for non-production workers. For Mauritius, an interpretation of the non-significance of the coefficient on human capital per worker suggests that its production workers had perhaps at that time reached the level of skills needed for their activities, so that training them further would yield little gains. This may happen when a country's labor force has a good educational background before reaching the labor market, so that the production sector of manufacturing that hires these workers does not have to invest much to make them highly productive. These results show that although both types of human capital can contribute to manufacturing growth, the level of human capital allocated to the non-production sector (research and management) is the most influential.

## Conclusions and Discussions

This study looked for evidence on the importance of the accumulation and allocation of human capital investment in promoting the creation of value-added in Sub-Saharan Africa's manufacturing industries. We used a model derived from Romer's endogenous growth theory to estimate the impact of human capital accumulation and allocation on manufacturing output and value-added in Ethiopia, Kenya, and Mauritius between 1969 and 1997. The model differentiated between the human capital going to the production sector (e.g., handling machines and cleaning) and the human capital going to the non-production sector (e.g., research and management) and was based on the theory that knowledge accumulation through research and management drives the growth of output and value-added per worker.

We found that the growth in value added per worker was positively correlated to the growth of human capital available to manufacturing in each country. More important, the investment in human capital going to the non-production workers was highly correlated to the output growth. Moreover, value-added per worker was highest where the investment in human capital going to research was the largest. The 'Food, Beverage, and Tobacco' industry, particularly in Ethiopia and Kenya, employed a relatively high level of skill, which contributed to higher growth of value-added per worker. The results also showed that growth of knowledge going to the non-production workers increased for Mauritius from 1970 to 1995 but has decreased for Ethiopia and Kenya since the mid-1980s.

If data were available, information on how the rates of return on human capital investment vary with other characteristics such as location, gender, ethnicity, and seasonality would have refined the results and made them more applicable. Similarly, schooling and a measure of the experience of workers if available could be better proxies for human capital. [7] Our use of wage differential entails some biases because wages and value-added can be highly correlated; the results of the endogeneity test, however, showed the bias was minimal. Also, when explaining cross-sectional difference in growth of output per worker, economists face the dilemma of choosing among existing growth models. [8] This problem has often been solved by testing the robustness (Temple, 1998) of the estimates under each of the relevant growth models, and users of panel data that model output growth are often criticized for not conducting such a robustness test. For this paper, our choice of the Romer model stems from its ability to capture both the accumulation and allocation of human capital.

Despite these imperfections born mainly out of data limitations, we draw two important implications for the prospect of manufacturing growth in Sub-Saharan Africa. One implication is that investments that bring about innovation and better management are keys to the growth in manufacturing industries. This is in line with the long-held view by Nelson and Phelps (1966) that it is the quality more than the quantity of human capital that spurs growth. Fafchamps and Söderbom (2006) drew attention to a labor management problem in Sub-Saharan Africa's manufacturing, where workers' efforts remain less responsive to supervisory action even as the supervisor-worker ratio is among the highest; they concluded that the problem arises not from a lack of education among the workers but from situations such as frequent

[7] In Braconier and Sjöholm (1998), the variable representing the growth of human capital is replaced by the level of R&D expenditures. Recently, schooling as a proxy to human capital has regained attention in the growth literature (Cohen and Soto, 2007), but such a dataset remains rare for many African countries' industries.

[8] Examples of studies setting up a framework to determine the best growth model supporting the data are Kocherlakota and Yi (1996) and Bleaney, Gemmell, and Kneller (2001). Many authors, however, agree that the true success of the robustness test still depends on the quality of the data, particularly on influential outliers and measurement errors. Without survey data, then, accurate representations of African manufacturing for economic analysis remain elusive. Promising advances in this direction

power outages, machine breakdowns, input shortages, and institutional deficiencies. This conclusion reinforces our findings especially with respect to the need to improve not just the number but the skill level of the technicians, supervisors, and managers who have to deal specifically with these technical and institutional difficulties. Another implication is that an increase in research and managerial skills is the best way to boost the production and export of skill-intensive, high-value goods. In an open economy, high endowment in managerial and research skills helps capture the R&D spillover effects of trade in manufacturing (Aghion and Howitt, 1992; Grossman and Helpman, 1991).

These findings and their implications convey the message that investment in human capital to acquire technical, managerial, and research skills is a decisive step to achieving strong manufacturing industries that create value added for employment and economic growth. Such a message needs to resonate in least developed countries endowed with abundant natural resources so that policy makers avoid the past mistakes of relying too heavily on volatile gains from raw material exports and instead tread the more stable paths of skill-based manufacturing to build prosperity.

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include the analysis in Söderbom and Teal (2000) and series of manufacturing surveys reported by Söderbom and Bigsten (2005) for several African countries

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**Table 1. Wage per Worker, and Repartition of Value Added in Manufacturing in 1996**

| Code ISIC | Manufacturing Industries | Ethiopia | | Kenya | | Mauritius | |
|---|---|---|---|---|---|---|---|
| | | Wage (birrs/year) | Value added % | Wage (shillings/year) | Value added % | Wage (rupees/year) | Value added % |
| 31 | Food, Beverages and Tobacco | 5979.4 | 52.4 | 3484.4 | 42.9 | 91206.2 | 28.0 |
| 32 | Textile, Wearing apparel,.. | 4141.5 | 18.5 | 3327.6 | 7.1 | 52818.8 | 48.2 |
| 33 | Wood and products | 4642.1 | 1.6 | 2966.7 | 1.9 | 78833.7 | 2.6 |
| 34 | Paper and products | 6389.0 | 5.3 | 5038.2 | 5.9 | 108982.7 | 4.1 |
| 35 | Chemical and plastics | 5764.9 | 6.4 | 6748.2 | 15.7 | 97865.9 | 5.5 |
| 36 | Pottery and glasses | 5222.3 | 7.6 | 5585.4 | 4.0 | 105646.1 | 4.2 |
| 37 | Basic metal | 7445.1 | 3.0 | 3238.5 | 0.6 | 101529.6 | 0.8 |
| 38 | Fabricated metal and machinery | 6325.4 | 3.9 | 5279.5 | 16.8 | 72956.5 | 4.7 |
| 39 | Other manufacturing | 4429.0 | 1.2 | 4332.7 | 5.1 | 45583.8 | 1.9 |
| | Total | | 100.0 | | 100.0 | | 100.0 |

Source: United Nations Industrial Development and Organization.

**Table 2. Structure of Exports, and Manufacturing Exports of Selected African Countries (Value in %)**

| **Sector** | **Country:** / **Year :** | **Ethiopia** 1995 | **Kenya** 1996 | **Mauritius** 1996 |
|---|---|---|---|---|
| Agriculture | | 79.2 | 50.0 | 1.2 |
| Mining Quarry | | 0.0 | 2.6 | 1.6 |
| Manufacturing Industries | | 20.8 | 47.4 | 97.2 |
| Food, beverages, and tobacco | | 3.7 | 13.7 | 30.5 |
| Textile | | 13.8 | 3.2 | 59.7 |
| Wood and products | | 0.0 | 0.6 | 0.1 |
| Paper and products | | 0.0 | 2.5 | 0.3 |
| Chemicals and plastics | | 3.2 | 15.6 | 0.8 |
| Pottery and glasses | | 0.0 | 3.1 | 0.3 |
| Basic metal | | 0.0 | 5.1 | 0.0 |
| Fabricated metal and machinery | | 0.1 | 3.1 | 2.7 |
| Other manufacturing | | 0.0 | 0.5 | 2.8 |
| Total Export Value | | 100.0 | 100.0 | 100.0 |

Source: United Nations Conference on Trade and Development Report.

## Table 3. Parameter Estimates of Romer Model for Manufacturing Growth

| Variables | Coeff. | Ethiopia (1969-97) | Kenya (1970-97) | Mauritius (1970-96) |
|---|---|---|---|---|
| Dependent variable: log of value added per worker | | | | |
| Intercept | $\theta_0$ | -4.781*** | -5.267*** | -2.488*** |
| | | (-24.70) | (-21.54) | |
| Time | $\theta_t$ | | | 0.030*** |
| | | | | (11.50) |
| Time dummy [a] | $D_t$ | -0.243*** | -0.708*** | |
| | | (-5.24) | (-3.30) | |
| Industry dummy: | | | | |
| Food, Beverage, and Tobacco | $\theta_1$ | 0.985*** | 0.415*** | -0.291 |
| | | (8.62) | (3.21) | (-1.57) |
| Textile, Wearing apparel, Footwear | $\theta_2$ | - | 0.078 | -0.520*** |
| | | | (1.25) | (-3.60) |
| Wood Product and Non-metallic fixtures | $\theta_3$ | 0.138 | - | - |
| | | (1.13) | | |
| Paper and products | $\theta_4$ | 0.639*** | 0.744*** | 0.163 |
| | | (5.39) | (8.98) | (1.24) |
| Chemicals, Oil refining, Rubber, Plastics,… | $\theta_5$ | 0.905*** | 0.784*** | 0.135 |
| | | (6.32) | (5.32) | (0.92) |
| Pottery, China, Non-metallic minerals | $\theta_6$ | 0.418** | 0.888*** | 0.166 |
| | | (2.56) | (5.78) | (1.22) |
| Basic metallic (Iron, Steel,…) | $\theta_7$ | 0.943*** | -0.483 | 0.230 |
| | | (11.10) | (-1.12) | (1.23) |
| Fabricated metal, Non-electrical and electrical machinery, Transport equipment,... | $\theta_8$ | 0.667*** | 0.230* | -0.047 |
| | | (4.15) | (1.80) | (-0.30) |
| Other manufacturing (Jewelry, Musical instruments, ..) | $\theta_9$ | not applicable | 0.739** | -0.325** |
| | | | (3.81) | (-2.06) |
| Human capital for research and management | $\theta_{HA}$ | 0.0220*** | 0.0012*** | 0.0014*** |
| | | (5.81) | (6.23) | (3.01) |
| Log of human capital for production per worker | $\theta_{hy}$ | 0.045*** | 0.072* | 0.0012 |
| | | (2.74) | (1.84) | (0.16) |
| Log of capital stock per worker | $\theta_k$ | 0.081*** | 0.202*** | 0.406*** |
| | | (4.94) | (5.22) | (11.84) |
| R-Square | | 0.74 | 0.86 | 0.90 |
| Total number of observations (NxT): | | 232 | 252 | 243 |

Notes. (.) are t-values; ***, ** and * are significance at the 1%, 5% and 10% levels, respectively.

a: For Ethiopia $D_t$ =0 before (not including) 1988, otherwise $D_t$ =1; For Kenya, $D_t$ = 0 before (not including) 1984 and $D_t$=1 otherwise. There is no break in Mauritius' time trend.