ELSEVIER
www.elsevier.com/locate/worlddev

CrossMark

World Development Vol. 64, pp. 713–725, 2014
0305-750X/

http://dx.doi.org/10.1016/j.worlddev.2014.07.004

Technology and Productivity in African Manufacturing Firms

SIMON BAPTIST [a] and FRANCIS TEAL [b,*]
[a] *The Economist Intelligence Unit, UK*
[b] *Centre for the Study of African Economics, University of Oxford, UK*

Summary. — We find that heterogeneity in production functions is an important source of variation in firm outcomes in Africa, and we find it is more important than education or productivity in explaining differences in output per worker. There is some technological diversity within Africa, with more dependence on raw materials in poor countries and higher returns to education in richer countries. This suggests that parameter evolution is an important element of modeling the nature of technical change, and that development policy should consider technological change as a mechanism to increase growth as well as augmenting factor stocks or total factor productivity.

Keywords — Africa, Ghana, manufacturing, firms, productivity, technology

1. INTRODUCTION

There is a large literature seeking to explain cross-country differences in output per worker, with the very low level of output per worker in Africa being a major motivating factor (Caselli, 2005; Caselli & Coleman, 2006; Easterly & Levine, 2001; Hall & Jones, 1999; Harrigan, 1999; Jerzmanowski, 2007; Young, 1994). A prominent theme of this literature has been the relative roles that technology differences and efficiency may play in explaining these income differences across countries. In this paper we adopt a very much narrower perspective by focusing on productivity and technological differences within African manufacturing. We show that even at this very disaggregated level productivity differences within and across African countries are substantial. We use a cross-country panel data set of manufacturing firms to investigate the nature of the heterogeneity in this particular segment of the economy. The manifestation of development processes in the form of technological heterogeneity in manufacturing on which we focus is the possible difference in the slope parameters of the production function. This is one element of microeconomic diversity that has not been fully investigated in the economic literature. We investigate the role of intermediate inputs in this heterogeneity within manufacturing firms in Africa and how their use varies across countries.

While there has been a focus on attempting to explain Africa's poor performance relative to the rest of the world at the macroeconomic level, there are substantial differences within Africa at the microeconomic level. Table 1 summarizes output per worker and value-added per worker for our sample of firms and also, for context, GDP per worker at the national level for the five countries considered in this paper. Clearly differences in manufacturing productivity are not closely related to GDP per worker as, for the countries in our sample, manufacturing is less than 16% of GDP. GDP per worker in South Africa is 21 times higher than that in Tanzania, while the level of output per worker at the firm level is over four times higher. There have also been significant differences in growth rates. Using PPP-adjusted GDP per capita as the measure, Tanzania was the poorest country in the sample. At the start and end of the period its GDP per capita was 56% and 23%, respectively, below that of Nigeria, the next poorest. This analysis seeks to ascertain the extent to which cross-country differences within Africa in inputs, technology, and productivity can explain the diverse outcomes observed in the manufacturing sector on the world's poorest continent.

Section 2 presents a basic analytical model to give a framework explaining why technology may differ across firms and countries. The term "technology" here refers to the set of the coefficients on the inputs in the production function. Total factor productivity (TFP) is modeled as a parameter that shifts the location of the production function, and it is allowed to differ over time, country, and by firm characteristics.

While a production function can incorporate many of the major factors determining the output of the firm, there are some firm-specific variables which remain unobserved, such as management skill. If these unobserved characteristics are correlated with input levels then endogeneity may be a concern. Fixed effects (FE) and system generalized method-of-moments (GMM) estimators are explored as possible mechanisms to remove any bias. Fixed effects estimation will remove any bias caused by firm-specific, time-invariant unobservables, such as management skill or initial conditions, while the inclusion of year dummies will account for time-specific unobservables common to all firms. The fixed effects estimator will still be subject to endogeneity bias from correlation between current period idiosyncratic firm-specific factors and current input levels. As we have panel data with a reasonable time dimension, the system GMM estimator (Arellano & Bond, 1991; Blundell & Bond, 1998) is used in an attempt to control for this latter type of endogeneity bias. This estimator exploits the autocorrelation structure of the residuals to provide instruments. Consider, for example, that current-period productivity shocks may be correlated with current input levels, but not with past input levels. Sufficiently lagged differences may then be used as instruments for contemporaneous levels while lagged levels are instruments for the equation in first differences. All standard errors are calculated in a way which is robust to heteroskedasticity and autocorrelation. In addition,

* We would like to thank Måns Söderbom for kindly giving us some STATA code for the translog regularity tests, the agencies which funded the collection of this data (see later), and the University of Tasmania and the Oxford–Australia Trust for funding. Final revision accepted: July 9, 2014.

Table 1. *Output per worker in Africa*

	Ghana	Kenya	Nigeria	South Africa	Tanzania
Micro					
Gross output per worker	18,948	61,919	80,553	106,811	23,663
Value-added per worker	6,981	22,042	15,935	45,964	7,307
Macro					
GDP per worker (2000)	2,775	2,476	1,479	21,998	1,014

Note: All data are measured in 1996 PPP$. The micro figures are sample averages of the firms used in this paper, while the macro data are from the Penn World Tables 6.1 (Heston, Summers, & Aten, 2002). Following the suggestion of Johnson, Larson, Papageorgiou, and Subramanian (2009) for comparison we use the version of the Penn World Tables with base year most consistent with the micro data.

the standard errors for the OLS and FE regressions have been calculated using a clustering method that allows for the errors to be correlated within firms observed in multiple time periods but independent between firms.

Section 3 takes the specification given in Section 2 to answer the question "does technology differ between countries within Africa?" Section 4 generalizes the Cobb–Douglas specification and introduces some dynamics into the production function to allow for a more precise characterization of the production process, and also in order to ascertain whether technology is truly distinct between countries. Having concluded that technology is indeed distinct, the role of education and material use will be considered. Section 5 concludes.

2. TECHNOLOGY CHOICE

The focus in this paper is on technological differences across manufacturing firms in Africa using panel micro data. This contrasts with the approach taken in the macro literature. At the macro level, the growth accounting approach has been dominant and takes as its starting point a value-added aggregate production function of the form:

$$Y_{it} = A_{it}K_{it}^{\beta}L_{it}^{1-\beta} \tag{1}$$

where i and t are subscripts for countries and years respectively, K represents the capital stock, L is the labor force, Y is value added, A is TFP and the coefficient β is assumed[1] to be equal to ⅓ (or a value close to this). Differences in output per worker between countries and across time can then be attributed to either differences in the amount of capital per worker or differences in TFP, with the relative roles of each subject of debate. In a comprehensive meta-study, Jorgenson (1990) finds that input growth accounted for most of the output growth in the United States over the period 1947–85, and notes that this finding is not confined to that particular country or time period. Young (1994) conducts a similar exercise for East Asia and also concludes that factor accumulation is more important than TFP. A contrary conclusion is reached by Easterly and Levine (2001), and much of the cross-country literature similarly finds that inputs are much less important than TFP. Many authors have noted that this is an unsatisfactory explanation as it is only identifying a proximate cause. If TFP does account for the large income differences across countries, then what we need to be concerned about is what underlying processes are being captured by TFP. We will find that accounting for intermediate inputs and technological heterogeneity at the microeconomic level is able to substantially reduce, if not remove, TFP differences between the five African countries considered in this paper at the sectoral level.

Caselli (2005) summarizes the puzzle in the cross-country productivity literature as one of inputs having insufficient explanatory power. Relaxing some of the assumptions implicit in Eq. (1), in an attempt to overcome this puzzle, is the subject of an extensive literature. For example: the measure of L can be augmented with measures of education (Hall & Jones, 1999) or the proportions of skilled and unskilled workers (Caselli & Coleman, 2006); the Cobb–Douglas functional form can be generalized (Jerzmanowski, 2007); or value added can be corrected for rents accruing to natural capital (Caselli & Feyrer, 2007). While the proportion of variation in output per worker attributed to TFP is generally reduced with each generalization, it still remains significant. Caselli (2005) surveys this literature and concludes that none of these generalizations can satisfactorily explain the wide TFP differentials.

Four possibilities for the lack of explanatory power of inputs in describing variation in output per worker are investigated in this paper: the true microeconomic sources are being masked by the aggregation process; heterogeneity in intermediate inputs has not been accounted for; technology is being incorrectly assumed to be homogeneous across countries; and, finally, the Cobb–Douglas functional form is inappropriate. Adopting a Cobb–Douglas specification to begin (this will later be generalized), the set of country-specific production functions for a sector is defined as:

$$lnY_{it} = \alpha_k^i + \beta_K^i lnK_{it} + \beta_L^i lnL_{it} + \beta_I^i lnI_{it} + \beta_M^i lnM_{it} + \varnothing^i(E_{it}) \tag{2}$$

The convex hull of Eq. (2) over all countries i is then the technology frontier across the countries in the data. Eq. (2) differs from Eq. (1) in that it allows the coefficients β and the function $\varnothing^i(E_{it})$ to differ across countries, explicitly includes human capital E, includes material and indirect inputs M and I, and uses gross output rather than value added as the measure of Y.[2] The framework of Eq. (2) is the basis for the intra-African analysis of this paper. The theoretical and empirical background to the four generalizations of the approach used to explain cross-country differences in output per worker at the microeconomic level is now discussed in turn.

First, we note that production is a microeconomic process. The microeconomic level will, depending on the precise question, generally be the appropriate one for the analysis of production. It may be that the characteristics of production that can explain cross-country differences are masked through some artifact of the aggregation process. There are now a large number of firm-level data sets available for a wide range of countries that have been used to investigate issues of productivity in individual countries (Chen & Tang, 1987; Hay, 2001 Shiferaw, 2009; Söderbom & Teal, 2004; Waldkirch & Ofosu, 2010). This paper extends this strand of literature by using data on manufacturing firms from multiple countries and, furthermore, by allowing the production function to differ across countries. This enables the identification of whether