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Factor demand, technical change and inter-fuel substitution in Africa

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ABSTRACT

The translog production function has been widely used in applied production analysis due to its flexibility and superiority over other functional forms. This study develops a translog production function for a group of African countries. The random effects model is estimated using generalized least squares estimator. The main findings are: first, output in Africa is driven by a more intensive use of petroleum and electricity and to a lesser extent capital, labor and coal; relative to technological progress. Second, African production technology exhibits 'increasing returns to scale' suggesting a path towards market entry barriers. Third, technical change is scale-biased and factor augmenting, albeit very slow. Fourth, all energy inputs are substitutes, indicating Africa's potential to proportionally switch towards cleaner fuels without adversely affecting economic growth. Finally and perhaps more generally, the study reinforces the assertion that imposing restrictions like homotheticity, homogeneity or separability on the production technology is unrealistic and should rather be a testable hypothesis within any applied analysis. In view of the documented findings, relevant implications for Africa are discussed.

Contents

1. Introduction

The critical challenges facing Africa in the 21st century include but not limited to environmental pollution, climate change, resource exhaustion, ecosystem deterioration, population growth, as well as the combined influence of these factors on energy

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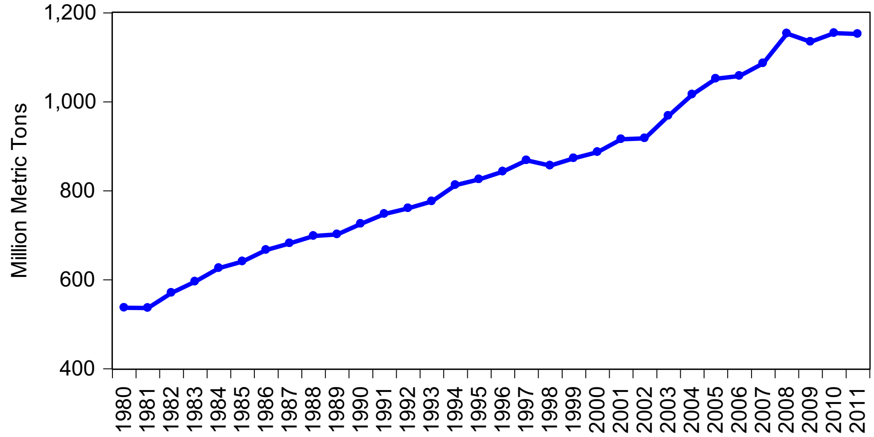

Fig. 1. Total African CO_2 emissions from the consumption of energy Source: US Energy Information Administration (EIA).

transformation. Despite Africa's economic growth which averages5%a year over the last ten years, poverty and inequity remain persisting problems challenging sustainable development, especially in Sub-Saharan Africa (ADB [1]). Hence, growth pathways that provoke strong changes in Africa's production and consumption patterns are necessary.

As part of a broader push for a more resource efficient and sustainable development, the African Development Bank (ADB) has placed the transition to green growth at the core of its new 10-Year Strategy (2013–2022).The resulting task then is how to speedily govern Africa's consumption of energy and its generation of waste and pollution, so as to minimize irreversible damages. Although Africa's emission of greenhouse gases (GHGs) is marginal and stands at less the 4% of the world's total (ADB [1]), carbon dioxide emissions from the consumption of energy in Africa have witnessed an increasing trend since 1980 (Fig. 1). Given its relatively low adaptive capacity and high climate sensitivity, indications are that increase in temperature would place Africa at the most vulnerable end.

State-of-the-art discussions among African policy makers on how to address resource consumption patterns and propel the continent's transition to green growth tend to focus on enhanced efficiency, renewable energy development and technical solutions. However, there is a growing consensus that efficiency improvements and technological progress are insufficient for dealing with Africa's current challenges. Furthermore, given Africa's thin financial resources and unreliable infrastructure, the relatively high costs associated with renewable energy technologies render them economically unattractive for solving Africa's energy problems. In fact, one must not forget that not only has there been a large number of failed renewable energy projects in Africa over the last 25 years, these projects have hindered development by raising expectations and then failing to deliver. As a result, overreliance on renewables, efficiency and technical advances could further escalate Africa's ecological dilemma by "*postponing more fundamental systemic changes and perpetuating a social and economic order that is fundamentally flawed*". What this seems to suggest is that the current level of consumption of some of Africa's resources needs to be drastically reduced.

Indeed, drastic reductions should not come at the cost of growth and the impacts of output growth and varying fuel prices on energy demand depend on inter-fuel substitution and substitutability between energy and other factors of production. Therefore, relying on review work of Omri [66] and Isa et al. [37], the objective of this study is to review and investigate the level of productivity in Africa and estimate output elasticities, returns to scale, elasticities of substitution and technical progress. Even though the results of most energy and climate change policy models are particularly sensitive to the elasticity of inter-fuel substitution, there is still a huge void in the literature dealing with demand and the elasticity of inter-fuel substitution parameters in Africa. Hence, this endeavor would provide an excellent platform for working on the following important questions for Africa: (i) what drives output? (ii) Does economics of scale exist? (iii) What are the elasticities of substitution among different fuel types? (iv) What is the nature of technical change: scale-biased or autonomous? (v) Is productivity affected by institutional regularities?

To provide perspectives on the above questions, this paper develops a transcendental logarithmic (translog) production function with panel data estimations for Africa.[1] Indeed, the originality and scientific contribution of this study adds value to the literature. First, in so far as the authors are aware, this is the first-of-its-kind approach to output growth and resource consumption for Africa in general. Second, this paper is one of the first to apply panel data to the translog production function in the energy economics literature.[2] As shall be explained later, previous studies which applied panel data to investigate energy substitution effects have all used the translog cost function. The notable exceptions are Wesseh and Lin [106] and Wesseh and Lin [107] who apply panel data to the translog production function to investigate the effectiveness of developing renewable energy for a group of African countries. Finally, another important feature that distinguishes this paper from previous studies in this field is that maintained hypotheses are tested as part of the analysis rather than assuming them to be true.

The rest of the paper is organized as follows: Section 2 reviews the relevant literature. Section 3 presents a discussion of the data. The model specification and estimation methodologies are presented in Section 4. In Section 5, the empirical results are reported. Section 6 discusses implications of the results for Africa and conclusions are drawn in Section 7.

2. Review of the literature

Two strands of literature are necessary for discussion; studies on energy consumption and economic growth as well as contributions documenting energy substitution elasticities.

[1] A panel data set contains observations on multiple entities (in our case countries),where each entity is observed at two or more points in time.

[2] For review of previous studies on the problem, interested readers are referred to Serletis and Timilsina [82]; Stern [96]; Smyth et al. [91,92]; Lin and Wesseh [46]; Wesseh et al. [103]; and Lin and Xie [51].