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Globalization and productivity: A robust nonparametric world frontier analysis☆,☆☆

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ABSTRACT

How to exit the economic recession and improve the economic condition in a globalized world is a central policy issue of importance. This paper examines whether countries that pursue outward orientation policies and that are increasingly economically integrated with the rest of the world have seen an increase in economic performance. Increasing globalization and interconnection among countries generates spatial and temporal dependence which will affect the production process of each country. We extend existing methodological tools – robust frontier in non parametric location-scale models - to estimate the world frontier of 44 countries over 1970–2007 and to obtain more reliable measure of productivity and efficiency to better investigate the driven forces behind the catching-up productivity process among countries. We explore the channels under which Foreign Direct Investment (FDI) and time affect the production process and its components: impact on the attainable production set (input-output space), and the impact on the distribution of efficiencies.

1. Introduction

The productivity slowdown in the US during the second half of the nineties, followed by the economic recession in 2001, more marked for Europe than for the US, has stimulated a great debate aimed at identifying its main causes and driving forces (see, e.g., OECD, 2007; van Ark et al., 2007). The understanding of the sources of growth may mirror the larger debate between the neoclassical and new growth theories, but economists generally agree that this recent decline has largely been caused by the weak growth in TFP, i.e., that part of the rise in productivity which is neither due to the increase in capital per labour employed nor to the rise in the labour skill level. Hence, total factor productivity has been recognized as the most important driver behind economic growth (Prescott, 1998; Caselli, 2005; Parente and Prescott, 2005).

World Bank (2008) defines economic globalisation as the rapid rise in the sharing of economic activities in the world between people of different countries. This has led to a contentious debate on whether countries that are increasingly economically integrated with the rest of the world have seen an increase in economic growth. Due to an increasing globalisation and interconnection among countries through history, geography and trade relations, Ertur and Koch (2007) demonstrate that technological interdependency generated by externalities is important in explaining conditional convergence process across countries.

The productivity analysis also recognizes an importance of investigating the spillover effects of the global shocks and business cycles. Mastromarco et al. (2013) among others, demonstrate that it is crucially important to take into account globalisation factors for an analysis of productivity and output growth. Furthermore, as countries tend to be influenced by their neighbours in a rather complex manner, such interlinkages render unrealistic the assumption of agents' homogeneity.

Recent developments have generated a growing empirical literature

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on methods for modelling these interlinkages among units in datasets with a panel structure by taking into account spatial or cross-section correlation.[1] The issue of cross section dependency or correlation has been widely discussed in the empirical panel data literature (Bai and Ng, 2006; Pesaran, 2006; Bai, 2009; Kapetanios et al., 2011). Due to a certain degree of cross-section dependence (CSD) introduced by unobserved (heterogeneous) time-specific factors the conventional estimators would be seriously biased. The literature deals with cross section dependence, attributable to economy-wide shocks that affect all units in the cross section but with different intensities, by assuming a multi-factor error process characterized by a finite number of unobserved common factors. According to this approach, the error term is a linear combination of a few common time-specific effects with heterogeneous factor loadings plus an idiosyncratic (individual-specific) error term.

Chudik et al. (2011) introduce the distinction between weak and strong cross section dependence. Specifically, a process is said to be cross sectionally weakly dependent at a given point in time, if its weighted average at that time converges to its expectation in quadratic mean, as the cross section dimension is increased without bounds. If this condition does not hold, then the process is said to be cross sectionally strongly dependent. The distinctive feature of strong correlation is that it is pervasive, in the sense that it remains common to all units however large the number of cross sectional units.[2]

Pesaran (2006) and Bai (2009) propose two alternative way to handle strong cross sectional dependence. Pesaran (2006) suggests a pooled common correlated estimator (PCCE) which approximates the linear combinations of the unobserved factors by cross section averages of the dependent and explanatory variables and then runs standard panel regressions augmented with the cross section averages. An advantage of this approach is that it yields consistent estimates even when the regressors are correlated with the factors, and the number of factors are unknown. Bai (2009) proposes a principal component (PC) interactive maximum likelihood estimator where the unobserved factors are identified by principal components.[3] More recently Pesaran and Tosetti (2011) have presented a panel model in which the errors are a combination of a multifactor structure and a spatial process, hence combining strong and weak CSD.

So far all of the studies analyzing effect of external common factors on productivity of countries have been in the stream of parametric modeling, However, the parametric approach suffers of misspecification problems when the data generating process is unknown, as usual in the applied studies, and the nonparametric methods often give the most reliable results. The purpose of this paper is to provide fully nonparametric location scale estimators of production frontiers and time variant technical efficiency in a dynamic framework which allows external and global (time specific) factors to affect technical efficiency.[4] Our model constitutes an attempt to introduce, in a simple way, cross sectional dependence and correlation into a fully nonparametric panel modelling framework.

There is a fundamental measurement problem for total factor productivity (TFP). The usual approach to estimate TFP is through growth accounting to explain output growth as the accumulation of factor inputs and the growth of TFP. However this approach has an important drawback since it does not consider non-competitive markets, increasing returns to scale and factor utilisation over the business cycle. More importantly, growth accounting interprets the TFP (Solow residual) as ”technical change“. The interpretation of the TFP as technical change is reasonable only if all countries are producing on their frontier. Beyond factor inputs, we could have additional determinants of output growth affecting the efficiency with which real inputs are transformed into output and thus directly affecting productivity. TFP comprises two mutually exclusive parts, technological change and efficiency change, and frontier model allows us to distinguish between the two. Moreover our frontier model enables us to see whether the effect of environmental/global variables on productivity occurs via technology change or efficiency. We can then quantify the impact of environmental/global factors on efficiency levels and make inferences about the contributions of these variables in affecting efficiency.

In a macroeconomics context, as the one used in this paper, where countries are producers of output (i.e., GDP) given inputs (e.g., capital, labor, and technology), inefficiency can be identified as the distance of the individual production from the frontier estimated by the maximum output of the reference country regarded as the empirical counterpart of an optimal boundary of the production set. The growth literature highlights that capital accumulation and technological diffusion play an important role in promoting economic growth, e.g. Nelson and Phelps (1966), Jovanovic and Rob (1989), Romer (1990), Segerstrom (1991), Barro and Sala-i-Martin (2004). Bernard and Jones (1996) demonstrate that technology catch-up, defined as individual countries' abilities to adopt and accumulate new technologies, will be a dominant factor in reaching the steady-state level of output growth. In general, technological diffusion is likely to play a significant role in spurring productivity growth by lowering barriers to flows of imported goods and foreign direct investment (FDI) (Borensztein et al., 1998; Cameron et al., 2005).[5] Inefficiencies generally reflect a sluggish adoption of new technologies, and thus efficiency improvement will represent productivity catch-up via technology diffusion.

Starting with Färe et al. (1994), efficiency frontier econometric studies on macroeconomic data using nonparametric approaches (like FDH or DEA) are not new (see, for example, (Kumar and Russell, 2002; Henderson and Russell, 2005; Henderson and Zelenyuk, 2007; Mallick et al., 2016)). Furthermore, there are various nonparametric and parametric frontier studies try to model the effect of environmental factors on production process and applying one stage or two-stage approaches to capture the heterogeneity caused by these factors (e.g. (Henderson and Russell, 2005; Henderson and Zelenyuk, 2007; Iyer et al., 2008; Kneller and Stevens, 2006; Blazek and Sickles, 2010; Wang et al., 2012; Mallick et al., 2016)).

We propose a flexible non parametric two step approach to take into account the cross section dependence due to common factors attributable to global shocks. Following recent development in non parametric conditional frontier literature Florens et al. (2014) we suggest a nonparametric location-scale frontier model linking production inputs and output to the global and environmental factors. In the first step we clean the dependence of inputs and outputs on global and other environmental factors. These time factors capture the correlation among units; by eliminating the effect of these factors on production process we mitigate the problem of CSD.[6]

In the second step we estimate the world frontier and the efficiency using inputs and outputs whitened from the influence of global shocks and endogenous environmental factors. We also define a robust version of the frontier estimates, robust to extreme and outlying values. By eliminating influence of external factors our nonparametric estimator

[1] Two main approaches are proposed: the residual multifactor structure and the spatial econometric approach.

[2] Spatial dependence typically entertained in the literature turns out to be weakly dependent in this framework.

[3] Bai (2009) examines the cross-section dependence in panels more extensively, and allows regressors to be correlated with both factors and loadings by including both additive and interactive fixed effects. He then proposes an estimation method in which the unobservable common factors can be consistently estimated by the principal components.

[4] The efficiency frontier literature defines environmental or external factors, those variables which might affect the production process but which are not under the direct control of the production unit.

[5] If knowledge transfers made available by FDI create efficiency externalities, such openness is expected to raise total factor productivity through efficiency gains.

[6] We follow Pesaran (2006) who shows that unobserved common factor, θ_t, can be consistently proxied by cross-sectional averages of dependent and independent variables as N, $T \to \infty$, and $T/N \to K$ with $0 \le K < \infty$.