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Financial development and productive inefficiency: A robust conditional directional distance function approach

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HIGHLIGHTS

- Can financial development effectively lower productive inefficiency?
- Using time-dependent robust conditional directional distance functions, the paper assesses this in a sample of 91 countries over 1970–2011.
- The effect of financial development on countries' productive inefficiency is highly nonlinear, depending on income levels.
- Higher levels of financial development are enhancing more countries' catching-up ability rather than their technological change.

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ABSTRACT

This paper examines whether the level of financial development helps lower countries' inefficiency using time-dependent robust conditional directional distance functions in a sample of 91 countries over 1970–2011. The overall results reveal that the effect of financial development on countries' productive inefficiency is highly nonlinear, and depends on countries' income levels, suggesting that higher levels of financial development are enhancing more countries' catching-up ability rather than their technological change.

1. Introduction

The relationship between financial development and economic growth has been well analysed in the literature for several decades (King and Levine, 1993). Goldsmith (1969) was the first study suggesting that this relationship can be bidirectional. However, several studies suggest that money causes output (Berger and Österholm, 2009; Shen, 2013; Beck et al., 2014). Maskus et al. (2012) explain the mechanism between financial development, innovation and economic growth relationship. Badunenko and Romero-Ávila (2013) provide a direct link between financial development and countries' aggregate levels of production efficiency. In their study, by applying the methodological framework of Kumar and Russell (2002), they construct a world production frontier for 57 countries over the period 1965–2005. Based on the theoretical framework of Badunenko and Romero-Ávila (2013), and the hypothesis that financial development drives growth, our study for the first time applies time-dependent conditional robust directional distance functions (Daraio and Simar, 2014; Mastromarco and Simar, 2015) to explore the effect of financial development on countries' productive inefficiency levels.

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We apply robust (*order-α*) quantile directional distance functions conditioned on time and financial development for a sample of 91 countries over the period 1970–2011. We examine potential nonlinear relationships by decomposing the effect of financial development on countries' technological change (shift of the frontier) and on countries' technological catch-up. As has been highlighted by Ang (2011) even though there is empirical evidence that financial development contributes to countries' economic growth, there is lack of empirical studies investigating the financial development–technological deepening relationship. To this end our paper contributes to the existing literature by filling this empirical gap incorporating the latest advances on robust nonparametric frontiers and providing empirical evidence on the effect of financial development on countries' technological catch-up and technological change levels.

2. Methodology

Let us consider countries' production process as a set of p inputs and q outputs. Then the production set of the technical feasible combinations can be represented as:

$$\Psi = \left\{ (x, y) \in \Re_+^{p+q} \middle| x \text{ can produce } y \right\}. \tag{1}$$

Then the Farrell output distance of (x, y) can be obtained as:

$$\lambda(x, y) = \sup\{\lambda > 0 | (x, \lambda y) \in \Psi\}. \tag{2}$$

By following Daraio and Simar (2014), we consider the joint probability measure of (X, Y) and the probability function $H_{XY}(.,.)$ defined as:

$$H_{XY}(x, y) = \text{Prob}(X \le x, Y \ge y), \tag{3}$$

then Ψ can be identified with the support of $H_{XY}(.,.)$ as:

$$\Psi = \left\{ (x, y) \in \Re^{p+q} \middle| H_{XY}(x, y) > 0 \right\}. \tag{4}$$

Furthermore, as it has been described in the related literature (Bădin et al., 2012; Daraio and Simar, 2014; Mastromarco and Simar, 2015) and in the presence of time and financial development, we can further define the probabilistic formulation for countries' production process introduced previously. Specifically, let $Z \in \Re^d$ denote the vector of factors/variables which is influencing the production process.[1] Furthermore, the time T as an additional conditional variable for each time period t defines the attainable set $\Psi_t^z \subset \Re_+^{p+q}$ as the support of the conditional probability:

$$H^t_{X,Y|Z}(x, y|z) = \text{Prob}(X \le x, Y \ge y | Z = z, T = t). \tag{5}$$

Then by following Daouia and Simar (2007) for any $\alpha \in (0, 1]$ with $F_X(x) = \text{Prob}(X \le x) > 0$ the order-α quantile estimation can be obtained as:

$$\lambda_\alpha(x, y) = \sup\left\{\lambda > 0 | S_{Y|X}(x, \lambda y) > 1 - \alpha\right\}, \tag{6}$$

where $S_{Y|X}(x, y) = \text{Prob}(Y \ge y | X \le x)$.[2]

Recently Simar and Vanhems (2012) have introduced the probabilistic version of directional distance functions and the link with the order-α distances. In a general framework, consider a positive directional distance vector $g = (g_x, g_y) \in \Re_+^{p+q}$ having the same unit as the input and output vectors[3]. Then the order-α output oriented distance function can be defined as:

$$D_\alpha(x, y; g_y) = \sup\left\{\beta | S_{Y|X}(x, y + \beta g_y) > 1 - \alpha\right\}. \tag{7}$$

The order-α directional distance function can also be written as:

$$D_\alpha(x, y; g_y) = \log\left(\lambda_\alpha(\tilde{x}, \tilde{y})\right), \tag{8}$$

where $\lambda_\alpha(\tilde{x}, \tilde{y}) = \sup\left\{\lambda > 0 | S_{\tilde{Y}|\tilde{X}}(\lambda\tilde{y}|\tilde{x}) > 1 - \alpha\right\}$, which is the order-$\alpha$ quantile estimator but in the $\tilde{x}, \tilde{y}$ coordinates.[4] Then the time dependent conditional order-α directional distance function can be obtained as:

$$D_{t,\alpha}(x, y; g_y|z) = \log\left(\lambda_{t,\alpha}(\tilde{x}, \tilde{y}|z)\right), \tag{9}$$

where $\lambda_{t,\alpha}(\tilde{x}, \tilde{y}|z) = \sup\left\{\lambda > 0 | S^t_{\tilde{Y}|\tilde{X},Z}(\lambda\tilde{y}|\tilde{x}, z) > 1 - \alpha\right\}$, which is the time dependent conditional order-α quantile estimator presented in Mastromarco and Simar (2015, p.831) but in the $\tilde{x}, \tilde{y}$ coordinates. Furthermore, values of $D_\alpha(x, y; g_y)$ and $D_{t,\alpha}(x, y; g_y|z)$ equal to 0 suggest that a country under evaluation is on the α-quantile frontier, whereas a positive value or a negative value indicates respectively that the country is below or above the quantile frontier. Then in a similar manner as in Daraio and Simar (2014, p363), we can analyse the effect of time and financial development by constructing the following differences:

$$\begin{aligned} \delta_{t,0.95}(x, y, z) &= D_{0.95}(x, y; g_y) - D_{t,0.95}(x, y; g_y|z) \\ \delta_{t,0.5}(x, y, z) &= D_{0.5}(x, y; g_y) - D_{t,0.5}(x, y; g_y|z). \end{aligned} \tag{10}$$

When choosing α value near unity ($\alpha = 0.95$) we analyse a robust version of the full frontiers levels and when we are choosing $\alpha = 0.5$ we can estimate the median of the distributions. In that respect when we are looking in a three dimensional picture[5] of $\hat{\delta}_{t,\alpha}(x, y, z)$ as a function of the elements of Z and T we are able to investigate the tendency of δ to increase or decrease with z and t. An increasing trend indicates a negative effect of z and t on the attainable set, whereas, a decreasing trend indicates a positive effect. Finally, as has been highlighted by Bădin et al. (2012); Mastromarco and Simar (2015) when investigating the differences of $\delta_{t,0.5}$ we analyse the effect of z and t on countries' catching-up levels (effects on the distribution of inefficiencies), whereas when investigating the differences of $\delta_{t,0.95}$ we investigate the effect on countries' levels of technological change (effects on the boundary/swift of the frontier).

3. Empirical findings

We use a sample of 91 countries[6] over the period 1970–2011. We consider here the simplest production model by using countries' aggregate capital stock, total labour force and GDP.[7] Following King and Levine (1993) and Arestis and Demetriades (1997), we use money and quasi money (M2) as a proxy for financial development.[8] Specifically we deploy money and quasi money as percentage of GDP (M2), extracted from World Bank WDI

1 In our case, it is countries' M2 levels as a percentage of their GDP.

2 It must be noted that when $a \to 1$ then $\lambda_\alpha(x, y) \to \lambda(x, y)$.

3 For our case since we use output oriented measures, the directional distance vector will take the form of $g = (0, g_y)$.

4 In order to obtain the output orientation we adopt a monotonic increasing transformation of the inputs/outputs as: $\tilde{x} = \exp(x)$, $\tilde{y} = \exp(y./g_y)$.

5 We apply a local linear estimator and for computational issues and selections of bandwidths, see Bădin et al. (2012) and Daraio and Simar (2014).

6 ARG, AUS, BDI, BEN, BFA, BHS, BOL, BRA, BRB, BWA, CAF, CAN, CHE, CHL, CIV, CMR, COD, COG, COL, CRI, DNK, DOM, ECU, EGY, FIN, FJI, GAB, GBR, GHA, GMB, GTM, HND, IDN, IND, IRL, IRN, ISL, ISR, ITA, JAM, JOR, JPN, KEN, KOR, KWT, LKA, MAR, MDG, MEX, MLI, MLT, MRT, MWI, MYS, NER, NGA, NLD, NOR, NPL, NZL, OMN, PAK, PAN, PER, PHL, PRY, QAT, ROM, RWA, SAU, SDN, SEN, SGP, SLE, SLV, SUR, SWE, SWZ, SYR, TCD, TGO, THA, TTO, TUN, TUR, UGA, URY, USA, VEN, ZAF, ZMB.

7 The data have been extracted from Penn World Table v8.1 (Feenstra et al., 2015).

8 Due to lack of consistent country-level data availability across different databases (PWT8.1 and WDI), we extracted our data sample for 91 countries over the period 1970–2011 for our analysis. As a robustness check we also use as a proxy of financial development the domestic credit to private sector (as % of GDP). We have compiled the variable from World Development Indicators within Datastream. Due to length restrictions the results are presented in the form of figures.