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Applying the New Metafrontier Directional Distance Function to Compare Banking Efficiencies in Central and Eastern European Countries

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ABSTRACT

This paper establishes a new metafrontier directional technology distance function (MDDF) under a stochastic framework, rather than a deterministic setting like the one proposed by Battese et al. (2004). The new MDDF allows for calculating comparable technical efficiencies for banks under different technologies relative to the potential technology available to the industry across nations. The inefficiency term of the new MDDF is further associated with relevant environmental variables of the form proposed by Battese and Coelli (1995). The new MDDF is then applied to examine and compare bank efficiencies of 17 Central and Eastern European countries. Non-performing loans (NPLs) are regarded as an undesirable, jointly produced with various loans, and the omission of them tends to underestimate technical inefficiency scores. Evidence is found that the estimated technology gap dominates technical efficiencies. Bank managers are suggested to swiftly adopt new financial innovations with an eye to shift the group frontier closer to the metafrontier.

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1. Introduction

Commercial banking is a very important service industry in a nation. A country having a healthy financial system is able to establish a stable, sound financial market, to deepen its financial development, and to avoid suffering from financial distress. Scarce loanable funds can thus be efficiently allocated to the most productive projects that prompt a nation's economic development. The presence of financial crises, such as the Asian financial crisis that occurred in 1997 and the global financial crisis starting in early 2007 when the sub-prime mortgage crisis erupted in the U.S., usually severely hurt the well-being of multiple countries, such as decreases in income and jobs. European banking has undergone fundamental changes over the last two decades. After the disintegration of the former Soviet Union in the 1990s, Central and Eastern European (CEE) countries have committed themselves to conducting various forms of financial reform, including privatization and the entry of foreign banks and investments, in an attempt to enhance the efficiency and productivity of their financial sectors, to promote corporate governance and the effectiveness of supervision, and to speed up a country's financial development and economic growth. Most CEE countries intended to restructure their banking systems by initiating large scale privatization programs in the mid-1990s in an attempt to encourage competition and efficiency of banks by increasing foreign and private domestic participation. Therefore, the managerial ability of financial institutions is an important issue worth a further investigation, given the promotion of competition from the presence of foreign banks in the CEE area and the improvement in the institutional, regulatory, and supervisory structure.

Most previous studies on the issues of bank efficiency and productivity change apply either the data envelopment analysis (DEA) or the stochastic frontier approach (SFA) to find the production or cost frontier. Recently, the directional technology distance function (DDF), proposed by Färe et al. (1997), has drawn much attention of empirical researchers. Almost all works, except for Koutsomanoli-Filippaki et al. (2009), adopt the DEA to investigate the efficiency and productivity of firms, and though DEA has several strengths such as being free from specifying a functional form, it is unable to separate the effect of random shocks on the estimated efficiency scores. Conversely, the SFA assumes composed errors that distinguish statistical noise from the technical inefficiency term, while it requires specifying a particular functional form.

Following Koutsomanoli-Filippaki et al. (2009), this paper applies the stochastic frontier DDF to investigate bank efficiencies in 17 CEE countries. The advantages of using this DDF are as follows. First, it characterizes the joint production of desirable outputs with undesirable outputs and allows for a bank to increase desirable outputs and concurrently decrease inputs and undesirables. This differs from either the input- or the output-oriented distance function that permits either input savings or output expansion, but not both, and is incapable of handling undesirable outputs. Second, the DDF is specified as if the translog form without the need to take the natural logarithm. This flexible functional form can lessen the potential error of functional specification and

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the sample with variables taking a zero value can hold. Finally, the inefficiency term can be linked with a set of environmental variables that influence a bank's production effeciency.

In the banking industry, non-performing loans may be viewed as an undesirable, by-product jointly produced with various loans. According to Färe and Grosskopf (2005), desirable outputs are said to be null-joint with undesirable outputs, if there are no bad outputs produced, then only zero good output can be produced. Furthermore, undesirables are assumed to be weakly disposed, i.e., the disposal of them needs to consume resources and is not costless. Consequently, the exclusion of undesirables from the model is apt to overestimate the technical efficiency score. For example, suppose that banks A and B are producing the same level of outputs, but bank A employs less number of workers than bank B to screen out its applicants for loans. This would result in the amount of bank A's non-performing loans to exceed bank B's. Taking an intput-oriented distance function as an example, it is very likely that bank A's efficiency score is greater than bank B's, since the former hires less labor than the latter to yield the same output quantities. If the bad output, satisfying the foregoing properties of null jointness and weak disposability, is explicitly taken into account, then the rank of the efficiency scores of the two banks may be reversed. This is because bank A has to consume some resources to deal with the bad output, lowering the output oriented technical efficiency measure.

The metafrontier, dated back to Hayami (1969) and Hayami and Ruttan (1970, 1971), is established on the basis that all firms in different production groups have access to the same, potential technology, but each may choose to operate on a different part of it. This may be attributed to the fact that each group (or country) has its own cultural and economic traditions, resource endowments, market structure characteristics, regulation, and political and law systems (Bolt and Humphrey, 2010; O'Donnell et al., 2008). These conditions hinder firms in different countries from selecting from the full set of technologically optimal input–output mixes in the potential technology set. Therefore, banking industries, for example, of different countries adopt heterogeneous, sub-technologies. In this context, their performance cannot be compared directly on the ground of group-specific frontiers. Another source of technological heterogeneity may be due to bank-specific features linked with, e.g., expenditures on R&D, the capacity to learn new knowledge, and the core competences (Cohen and Levinthal, 1989; Kontolaimou and Tsekouras, 2010).

To validly conduct a cross-country comparison, a researcher has to design a procedure that takes care of heterogeneous technologies, on the one hand, and that the performance of banks should be assessed on the same benchmark for different countries, on the other. This requires the use of the newly developed metafrontier model by Battese et al. (2004) and O'Donnell et al. (2008), which proceeds in a two-step procedure. In the first step, the stochastic frontier of each country (or group) is estimated to yield technical efficiency scores for all banks within the individual countries. In the second step, one estimates the metafrontier to obtain the technology gap ratios (TGRs) between the (deterministic) metafrontier and the group frontiers for each bank, using the linear or quadratic programming technique that allows for easily imposing the tangency restriction between the metafrontier and the group frontiers. Bos and Schmiedel (2007) apply this model to examine banking efficiency in 15 Western European countries accounting for potential differentials among country-specific banking technologies.

We extend the stochastic frontier DDF of Koutsomanoli-Filippaki et al. (2009) to the new metafrontier DDF (MDDF), which allows for estimating and comparing bank efficiency across 17 CEE countries. The idea of the new MDDF is first proposed by Huang et al. (2014) exemplified by a production function. It differs considerably from Battese et al. (2004) and O'Donnell et al. (2008) mainly in the second step, aiming at establishing the (stochastic) metafrontier. Our new MDDF is constructed under the stochastic frontier framework, instead of relying on mathematical programming techniques. The primary difficulties of programming techniques are that they are deterministic, similar to the DEA, such that the estimation results are easily confounded with random shocks, and that no statistical inferences can be made, because the statistical properties of the estimates are unknown. Both difficulties can be disentangled by the employment of the new MDDF, to be thoroughly discussed in Section 3.

The purpose of this paper is three-fold. First, we attempt to build a new MDDF under the stochastic frontier framework. The new MDDF is recommended and possibly preferable, because the resulting estimates of TGRs are free from the influence of random shocks. Second, the TGRs can be further specified as a function of an array of exogenous variables characterizing the environments in which production takes place. This approach is akin to Battese and Coelli (1995). In this manner, one is able to study the determinants of the TGRs and, more importantly, banks from different countries can be compared under similar condisitons. Third and finally, the new MDDF is applied to estimate and compare bank efficiencies of 17 CEE countries, as banks in these transition nations tend to adopt heterogeneous technologies due to systematic, cultural, regulatory, and endowment differences, and the financial systems in these countries have experienced various series of financial reforms during the past two decades.

The rest of this paper is organized as follows. Section 2 briefly reviews relevant literature on the DDF and MDDF. Section 3 establishes the new MDDF. Section 4 describes the data. Section 5 analyzes the empirical results, while the last section concludes the paper.

2. Literature Review

2.1. Applications of the Directional Distance Function

Färe et al. (1993) derive a formula suitable for calculating shadow prices of undesirables, which can be empirically estimated by linear programming.[1] Most existing works estimating technical efficiency, on the basis of the directional distance function (DDF), require solving a linear programming problem. Chung et al. (1997) study the Malmquist-Luenberger productivity index (MLPI) of 39 Swedish pulp and paper firms over the period 1986–1990 and find that the main source of their productivity gains comes from technological progress. To highlight the importance of undesirable outputs, Färe et al. (2001) estimate the MLPI of the manufacturing sector of the U.S. covering 1974–1986, confirming that the MLPI is seriously underestimated if the model ignores undesirable outputs.

Yu (2004) consider both undesirables and environmental factors in his directional output distance function to measure the physical efficiency of Taiwan's airports. Comparing to the conventional output-oriented DEA method, his model leads to a large increase in the estimated efficiency scores for the sample airports, echoing the results of Färe et al. (1989). This may be attributed to the fact that firms (airports) must reallocate inputs not only to execute pollution control activities, but also to maintain desirable outputs' production activities in response to the imposition of a weak disposability constraint on undesirables. As a result, the efficiency measures obtained from the DDF are likely to reflect true production efficiency of the sample firms.

Watanabe and Tanaka (2004) employ a directional output distance function to evaluate the efficiency of the Chinese industry at the provincial level spanning from 1994 to 2002 under the framework of the DEA.

[1] In general, there are no market trading undesirable outputs, and hence their market prices are unobserved. However, their implied prices can be theoretically established from economic models and are referred to as shadow prices. The shadow price is useful to assess the effectiveness of existing regulatory measures and helps managers decide whether to buy pollution rights or not.

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