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Incorporating risk into bank efficiency: A satisficing DEA approach to assess the Greek banking crisis

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ABSTRACT

This paper is motivated by recent concerns, prompted by the recent financial crisis, that regulatory capital guidelines on loan loss reserves can generate dysfunctional outcomes and, moreover, by the fact that the Greek bonds held by the banks have an important impact on the risk level of the bank portfolio. The purpose of this paper is to incorporate risk into bank efficiency and to provide a snapshot of the efficiency profile of the Greek banking industry. Efficiency is measured by means of a *satisficing* data envelopment analysis (DEA) model in which the financial risk is proxied by credit risk provisions and by the participation of banks in the Private Sector Involvement (PSI), a controllable and an uncontrollable factor by the bank management, respectively. The results of the proposed probabilistic DEA model derived through the Monte-Carlo simulation are compared with the results of the respective deterministic model. As the constructed stochastic frontier screens further some of the 'best-in-class' banks, the merit of the proposed metric is evident.

1. Introduction

The banking industry plays a central role in the economy and, thus, the problems related to bank performance are the focus of a large body of literature. This paper is motivated by recent concerns, prompted by the recent financial crisis, that regulatory capital guidelines on loan loss reserves can generate dysfunctional outcomes and, moreover, by the fact that the Greek bonds held by the banks have an important impact on the risk level of the bank portfolio. As such, it aims to incorporate risk into the bank efficiency and to provide a snapshot of the efficiency profile of the Greek banking industry and, thus, to assess the banking crisis.

The landscape of the Greek banking industry has changed substantially since 2001, when Greece joined the European Union's Economic and Monetary Union (EMU). The transformation from a heavily regulated into an outward-looking sector gave rise to a much stronger competition and attracted new entrants to the market. Greek banks have become attractive targets for mergers and acquisitions (M&A) and these M&A have resulted in larger banks that are able to reap the benefits of the possible economies of scale and scope and compete more effectively. The competition among the major Greek banks has intensified over the recent years. The focus has been on retail banking, with banks enlarging their products and services, improving service quality, modernizing and expanding their branch networks and alternative distribution channels, investing heavily in new technology, and improving their internal processes (Giokas & Tsolas, 2008).

In April 2011, the Greek financial system comprised 62 credit institutions. In the Greek banking sector there were 18 Greek commercial banks, 16 cooperative banks, branches of 22 banks from EU countries, 5 branches from non-EU countries, and 1 specialized credit institution, namely the Consignments and Loans Fund (HBA, 2011). The Greek financial system is characterized by a high degree of concentration. Since 2001 when Greece joined the Eurozone the four largest players, namely National bank, EFG Eurobank, Alpha bank, and Piraeus bank, have developed rapidly through penetration in the Southeastern Europe's countries. This strategy was followed until the 2008 financial crisis and it was in a different direction compared to the movements of other countries' financial institutions, such as the US and UK, for example, which invested their assets in "toxic" products. However, the development of the 2008 crisis led to the collapse of the inter-bank confidence in Greece, which ended credit liquidity. The banking system used Greek bonds to improve its liquidity and the downgrading of bonds directly affected the liquidity of the banking system. As the crisis affected the financial system, the state offered "support packages"

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to the banks to enhance their liquidity and to limit the extent of the economic suffocation of the market. The Greek economy had appeared weakened since 2007 mainly due to the reduction in investments as a result of inflated private investment in housing in 2006. The 2008 crisis hit an already weak Greek economy with a high fiscal deficit in the preceding years and this caused a decrease in the domestic demand, threatening the banking industry and further aggravating public finances. The internal conditions of the crisis can be distinguished into the following factors: (i) the public debt and its maturity; (ii) the increase in the spreads for the Greek bonds (i.e., 10-year bonds) as compared to the German bonds; (ii) the evolution of derivative prices based on these bonds; and (iv) the credit rating of Greece by rating agencies such as Fitch, Standard & Poor's, and Moody's (Petrakis, 2012).

The efficiency measurement of the banking industry by means of operational research methods such as data envelopment analysis (DEA) has attracted a lot of research attention as evidenced by the large bulk of literature (Fethi & Pasiouras, 2010). DEA (Charnes, Cooper, & Rhodes, 1978) is an empirical non-parametric multi-input multi-output method for constructing production efficient frontiers and assessing the relative efficiency of entities (i.e., firms, banks, among others) known as decision-making units (DMUs). In their contribution titled "Data envelopment analysis 1978–2010: A citation-based literature survey", Liu, Lu, Lu, and Lin (2013) surveyed the DEA literature to discover, among others, the latest active DEA subareas. It is interesting to note, therefore, that the five subareas identified are "two-stage contextual factor evaluation framework", "extending models", "handling special types of data", "examining the internal structure of the DMUs", and "measuring environmental performance".

During the past decades, there have been many applications of DEA methods to assess the relative efficiency of the banking sector (for more information, the reader is referred to Berger, 2007; Drake, Hall, & Simper, 2009; Fallah, Aryanezhad, Najafi, & Shahsavaripour, 2011; Haslem, Scheraga, & Bedingfield, 1999; Maudos & Pastor, 2003; Mercan, Reisman, Yolalan, & Burak Emel, 2003; Resende & Silva, 2007). A stream of the related literature has examined the relationship between risk and efficiency by incorporating in the efficient frontier various aspects of risk (Koutsomanoli-Filippaki & Mamatzakis, 2011). In more recent contributions, Yang, Wong, Xu, Liu, and Steuer (2010) introduced an integrated bank performance assessment and management planning, Das and Kumbhakar (2012) studied the productivity and efficiency of Indian banks using hedonic aggregator function and Titko (2014) aimed to investigate the relationship between bankś size and efficiency scores. Furthermore, LaPlante and Paradi (2015) introduced five VRS DEA models to investigate three perspectives of bank branch growth. A variant of DEA models on banking applications can be seen in Kao and Liu (2014), who developed a model, based on the network DEA approach, to measure the overall efficiency of 22 Taiwanese commercial banks, and in Halme, Korhonen, and Eskelinen (2014), who developed a new approach to value efficiency analysis and applied it to the analysis of bank branch performance.

DEA conventional models do not allow stochastic variations in input and output data, such as measurement errors, and data entry errors, among others. In order to take into account stochastic variations in the data, many authors (Banker, 1986; Cooper, Huang, Lelas, Li, & Olesen, 1998; Cooper, Huang, & Li, 1996; Grosskopf, 1996; Olesen, 2006; Olesen & Petersen, 1995) have concentrated on applying chance-constrained programming to DEA. It is worth pointing out, however, that other ways of dealing with uncertainty in DEA include goal programming (Huang & Li, 1996), fuzzy sets theory (Kao & Liu, 2000; Lertworasirikul, Fang, Joines, & Nuttle, 2003), the assurance region concept (Despotis & Smirlis, 2002), joint probabilistic constraints (Bruni, Conforti, Beraldi, & Tundis, 2009), local maximum likelihood estimation (Simar & Zelenyuk, 2010), and Monte Carlo simulation (Kuah, Wong, & Wong, 2012; Wong, 2009). In this context, more recently, Wen, Guo, Kang, and Yang (2014) proposed a new uncertain DEA model as well as its equivalent crisp model to deal with uncertain inputs and outputs, while Tavana, Khanjani Shiraz, and Hatami-Marbini (2014) proposed a new chance-constrained DEA model with birandom input and output data. However, in spite of its wide applicability, *satisficing* DEA has not been well explored. In this paper, efficiency is measured by means of a SDEA model, namely a *satisficing* DEA model (Cooper et al., 1996), whereas risk proxied by credit risk provisions is modeled as a stochastic variable.

Over the last couple of years, the Greek banking industry faced the combined effects of some adverse factors, such as the cut-off from international markets and deposit outflows, adverse economic conditions, which resulted in deteriorating asset quality and the restructuring of the Greek sovereign debt through the Private Sector Involvement (PSI). The Greek banks participated in the PSI (i.e., in the exchange of Greek Government Bonds (GGBs) with a series of new bonds, at a significant price discount) in the context of the restructuring of the Greek sovereign debt. The above factors put pressure on the liquidity and the capital base of Greek banks threatening the stability of the industry and the long-term sustainability of several banks.

The aim of this research is to incorporate risk into the bank efficiency and to provide an ex-post evaluation of the efficiency profile of the Greek banking industry. Efficiency is measured by means of *satisficing* DEA, whereas risk is the stochastic variable proxied by credit risk provisions and, moreover, haircut losses on Greek bonds held by banks participating in the PSI are treated as an uncontrollable (deterministic) input.

The article has the following structure: the next sub-section deals with the literature review. The required DEA methodology along with the stochastic simulation concept and necessary metrics are described in Section 2. Section 3 presents the data involved in the analysis and Section 4 discusses the empirical findings of an application to the Greek banking industry and further includes the main implications for the industry. The final section derives the conclusions in support of the empirical findings.

2. Literature review

DEA stipulates that an evaluated DMU is not efficient in producing its outputs from giving amounts of inputs, if there is another DMU or a combination of DMUs that can produce more of some output without producing less of any other output and without utilizing more of any other input. Extensions of the first DEA model, namely the CCR model (Charnes et al., 1978), can be found in Thanassoulis (2001), Hadad, Friedman, and Israeli (2004), Hadad, Friedman, and Israeli (2005) and Cooper, Seiford, and Tone (2007).

The CCR model and its extensions known as conventional DEA models do not allow stochastic variations in the input and output data, such as measurement errors, and data entry errors, among others. Among competing efficiency estimation methods of DEA the stochastic frontier analysis (Aysan, Karakaya, & Uyanik, 2011) offers the possibility for specification error as it requires the assumption of some underlying functional form for the multi-input single-output case. To fill this research gap some authors developed DEA models to incorporate such stochastic variations in the input and output data; see Sengupta (1982), Banker (1993) and Sueyoshi (2000), among others.

In a new research stream SDEA is approached by means of *chance-constrained programming* (CCP) developed by Charnes and Cooper (1963) and Kall (1976). The contributions to that were those made by Sengupta (1989) and Land, Lovell, and Thore