



# Exploring the source of metafrontier inefficiency for various bank types in the two-stage network system with undesirable output



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## ABSTRACT

This paper integrates the production and intermediation approaches to define the inputs, intermediates, desirable and undesirable outputs of banks and to develop a new approach to decompose metafrontier inefficiency in a two-stage network system. This approach can help explore the sources of metafrontier inefficiency for managers of various banks. The empirical results demonstrate that foreign banks do not have efficiency as high as we expected in developed countries. These results also indicate that domestic banks enjoy a strong competitive advantage in the first stage; however, in the second stage, domestic banks' operational performances are worse than those of foreign banks when the meta-technology set is used as the evaluation basis for the 2004–2009 period. However, the production and operational performances of foreign banks outperform those of domestic banks when the meta-technology set is used as the evaluation basis for the 2010–2012 period. The production and operational inefficiencies of the metafrontier are derived from the managerial inefficiency of domestic and foreign banks from 2004 to 2009; however, the operational inefficiency of the metafrontier stems from the technical gap between the metafrontier and group frontiers in the second stage in domestic banks from 2010 to 2012.

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## 1. Introduction

With the market changing constantly, the financial services industry in Taiwan has experienced several significant turning points following the introduction of an open policy in 1990 that established private banking to the passing of the *Financial Holding Company Act* in 2001. Moreover, the financial services industry has demonstrated a high level of homogeneity with an insufficient level of innovation, due to the limitations placed on domestic financial institutions by the prior financial legislation. Furthermore, because of the failure to control the number of new financial institutions effectively since the opening of the financial market in 1990, compounded by the constant trend of low interest rates in recent years, there has been a reduction in deposits and an increase in bad loans; this reduction has resulted in an increasingly competitive financial market. Additionally, banks play an indirect but crucial financing role in the current financial market; therefore, any management crisis will lead to an unprecedented degree of internal financial turmoil and external social cost, which could cause a greater financial crisis. The most famous case is that of the subprime mortgage crisis in the US in August 2007, which not only resulted in the insolvency of Lehman Brothers

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but also further influenced the global financial market negatively. Thus, the improvement of the management performances of banks enables them to have a solid financial foundation and avoid the potential triggers of financial crises.

Performance measures can assess relative efficiency and identify the main reasons for inefficient firm management. A number of approaches can be used to assess the banking industry including financial ratio analysis, data envelopment analysis (DEA), and the stochastic frontier approach (SFA). Compared with ratio analysis and the SFA, DEA is considered a better means to analyse performance because it can produce multiple outputs using multiple inputs, and requires no prior assumption regarding the specification of the best practice frontier (Sherman and Gold, 1985). Therefore, many studies have used DEA to evaluate efficiency and productivity. Moreover, the existing literature on bank efficiency has focused on economies of scale and scope (Berger and Humphrey, 1991; McAllister and McManus, 1993), total productivity (Fukuyama et al., 1999; Sanyal and Shankar, 2011), the efficiency of bank branches (Camanho and Dyson, 1999; Yeh, 1996), and the impact of financial reform on efficiency and productivity (George Assaf et al., 2013; Hsiao et al., 2010; Isik and Kabir Hassan, 2003; Tsang et al., 2014; Williams and Nguyen, 2005). These studies have assumed that the production process of a bank is a black box and that it ignores immediate production processes. Therefore, recent studies have subdivided the production processes of banks into two stages to assess simultaneously the efficiencies of these different stages (Avkiran and Goto, 2011; Matthews, 2013). In recent years, an increasing number of academic studies have demonstrated that the undesirable outputs have a significant impact on the performance evaluations of banks (Assaf et al., 2013; Barros et al., 2012; Fujii et al., 2014; Fukuyama and Weber, 2010; Park and Weber, 2006). In practice, borrowers are occasionally unable to repay their loans from financial institutions in economic downturn; thus, desirable and undesirable outputs are likely to be generated in the banks' operation processes.

In addition to the information on the immediate production between stages and the consideration of the impact of undesirable outputs, the assumption that all decision-making units (DMUs) possess the same level of production efficiency frontier (production technology) is another emerging issue. The abovementioned assumption may lead to an inappropriate efficiency frontier (benchmark) for the nature of both different institutional environments and the production frontier among various banks. Consequently, the first objective of this paper is to extend the metafrontier concept (Chen, 2012; O'Donnell et al., 2008) to the two-stage DEA model (Fukuyama and Weber, 2010; Luo, 2003; Seiford and Zhu, 1999); it incorporates the undesirable outputs to measure the production and operational efficiencies of various bank formats in Taiwan from 2004 to 2012. In addition, the second objective of this paper is to provide a detailed overview of the time-series pattern change in bank efficiency. Based on information from the *Taiwan Economic Journal* (TEJ) database, banks in Taiwan can be organised into two groups: domestic and foreign. Certain studies have demonstrated that foreign banks will have higher efficiency when compared with domestic banks in emerging or developed economies (Akin et al., 2013; Staikouras et al., 2008; Sturm and Williams, 2010). Because Taiwan is a developed country, we expect that the same phenomenon will be present in other developed economies worldwide. Therefore, the third objective of this paper is to investigate whether the management performance of foreign banks is better than that of their domestic peers in Taiwan. Finally, this paper develops a new approach to define the technical inefficiency of the metafrontier and to explore the source of metafrontier inefficiency. This approach can notify bank managers regarding whether technical inefficiency is the result of a DMU's managerial inefficiency or a structural problem due to the different levels of technology.

The remainder of this paper is organised as follows. A literature review is presented in Section 2. Section 3 introduces the methodological models used in the paper including the metafrontier and group frontiers of the two-stage network directional distance function. The empirical results are presented in Section 4, and Section 5 presents our conclusions and final remarks.

## 2. Literature review

### 2.1. Two-stage DEA application in practice

Though Farrell (1957) pioneered the DEA of the production frontier, it was Charnes et al. (1978) who generalised Farrell's measure of single output efficiency into multiple outputs, which DEA consolidated. Therefore, DEA has already been widely used in various organisations and industries (Hsu and Hsueh, 2009). Nevertheless, the conventional DEA model often regards the production system as a black box that considers only a one-stage process. In practice, many production processes, such as those in the financial services sector, need more than one stage to reflect sufficient management information (Fukuyama and Matousek, 2011; Fukuyama and Weber, 2010).

Wang et al. (1997) pioneered intermediate production processes (i.e. two-stage DEA) to assess the impact of information technology on bank performance. The results of a numerical illustration found that the budget values of information technology have a significant impact on bank profits. In addition, Seiford and Zhu (1999) adopted the two-stage DEA method to assess the management performances of 55 commercial banks in the US. They divided the production processes of these banks into two stages: profitability and marketability. Their results showed that larger banks had better management performance in the profitability stage, whereas smaller banks had better performance in the marketability stage. Zhu (2000) proceeded to analyse the financial performances of the best 500 companies, as ranked by *Fortune* magazine, with a three-stage DEA. The results showed that the companies with the highest revenue did not necessarily have the top-ranked performance, in terms of profitability and marketability, and that most companies displayed not only serious technical inefficiencies, but also serious scale inefficiencies.

Luo (2003) posited that most previous studies of bank efficiency focus on profitability efficiency, ignoring marketability efficiency. Therefore, this study adopted a sample of 245 large banks in 2000 to evaluate both profitability and marketability efficiencies. Its empirical results showed that the source of bank inefficiency is marketability efficiency, rather than profitability efficiency; the geographical location of banks seems to be unrelated to either profitability or marketability efficiency; and overall technical profitability

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