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Measuring cost efficiency in presence of heteroskedasticity: The case of the banking industry in Taiwan

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ABSTRACT

We measure cost efficiency of commercial banks in Taiwan using annual data for the 1996–2011 period. Following Caudill et al. (1995), and Caudill and Ford (1993), we develop a generalized dynamic model that accounts for heteroskedasticity in the cost inefficiency component of the error term in the stochastic frontier (SF) model and adopt a single-step approach (e.g., Battese and Coelli, 1995; Wang and Schmidt, 2002) to circumvent the problems associated with the two-step estimation procedure used by prior studies. We show that the results based on the heteroskedastic stochastic frontier (HSF) model combined with the single-step estimation approach sharply contrast with that of the traditional 'two-step' approach. These are important findings because they point to the limitations of previous studies on cost efficiency that use a two-step estimation approach. Our findings suggest that asset size, loan quality, and bank equity-to-asset ratio have significant negative impact on cost efficiency of banks. Government-owned banks in Taiwan are more likely to be cost efficient than privately owned banks. Macroeconomic environmental factors such as money supply and foreign exchange reserve ratio are likely to influence the cost efficiency of banking industry in Taiwan.

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1. Introduction

A large body of literature spanning over the past three decades addresses banking efficiency in the United States (e.g., Berger and Humphrey, 1997; Berger and Strahan, 1998); Europe (e.g., Allen and Rai, 1996; Pastor et al., 1997; Altunbas et al., 2001b); Asia-Pacific region (e.g., Bhattacharya et al., 1997; Rezvanian and Mehdian, 2002; Berger et al., 2009; Lin and Zhang, 2009); and in transitional economies in Eastern Europe (e.g., Bonin et al., 2005; Havrylchyk, 2006; Yildirim and Philippatos, 2007). The empirical literature in general provides mixed evidence on cost efficiency of banks. For example, Bonin et al. (2005) find that domestically owned private banks are not significantly more cost efficient than government owned banks in Central and Eastern European countries. In contrast, Yildirim and Philippatos (2007) report that domestically owned private banks and state-owned banks are less cost efficient relative to foreign banks in transition countries. Havrylchyk (2006) finds that foreign banks that acquired domestic banks in Poland do not enhance cost efficiency. In the case of mainland China, Berger et al. (2009) and Lin and Zhang (2009) find that the Big Four state-owned banks are less cost profit efficient relative to domestically owned private banks. In contrast, Yung-Ho and Chen (2009) analyze the bank efficiency of Taiwanese banks over the 2002–2004 period and find that the mean efficiency score of government-owned banks is higher than that of privately owned banks.

Although several methods are available to measure cost efficiency in banking, the stochastic frontier (SF) approach introduced by Aigner et al. (1977) and Meeusen and Van Den Broeck (1977) has received increased attention among researchers over the last two decades (e.g., Cebenoyan, 1990; Ferrier and Lovell, 1990; Greene, 1993; LeCompte and Smith, 1990; Bauer, 1990; Berger and Humphrey, 1991; Weiss, 1991; Berger, 1993; Mester, 1993, 1996; Allen and Rai, 1996; Rai, 1996; Resti, 1997). The econometric approach for the estimating stochastic cost frontier model requires the separation of random errors from the systematic error component of a specified cost function. This entails the specification of a particular distribution form. The basic SF model assumes that a firm's observed cost deviates from the optimal cost due to a random noise (v_i) and an inefficiency component (u_i). It is usually assumed that u_i and v_i are independently and identically distributed. Further, the model assumes that v_i is normally distributed with a mean zero and constant variance, $v_{it} \sim N(0, \sigma_v^2)$, and the u_i is half-normally distributed, meaning the u_i is the absolute value of a variable that is normally distributed with a mean zero and constant variance, $u_i \sim |N(0, \sigma_u^2)|$. With these distributional assumptions, the basic stochastic econometric cost frontier model can be estimated using maximum likelihood techniques. Once the model is estimated, inefficiency measures can be estimated using the conditional mean of the inefficiency term, u_i, as proposed by Jondrow et al. (1982) or Greene (1993).

A vast number of studies measuring cost efficiency have used the basic SF model described above (e.g., Murray and White, 1983; Mester, 1987, 1993; Cebenoyan, 1990; LeCompte and Smith, 1990; Berger and Humphrey, 1991; Weiss, 1991; Resti, 1997; among others). Following Pitt and Lee (1981), several studies have used basic SF model and a two-step estimation procedure (e.g., Allen and Rai, 1996; Rai, 1996; Berger and DeYoung, 1997; Berger and Mester, 1997; Resti, 1997; DeYoung and Hasan, 1998; Bos and Kolari, 2005; Lieu et al., 2005; Bonin et al., 2005; Yildirim and Philippatos, 2007; Berger et al., 2009; Lin and Zhang, 2009 among others) to study the effects of macroeconomic variables and bank-specific factors such as size, ownership, and branch banking on cost inefficiency of banks. In the first step, the optimal stochastic frontier cost model (basic SF model) is estimated. In the second step, macroeconomic and the firm-specific variables are regressed on bank inefficiency to identify the factors affecting it.

However, the literature on efficiency analysis has raised two major issues associated with estimates of inefficiency based on (1) the use of the basic SF model and (2) the two-step estimation procedure described above.[3] First, the standard stochastic econometric frontier model (basic SF model) used in prior studies can lead to biased results because it does not account for heteroskedasticity in the inefficiency component of the error term, u_i (e,g., Caudill and Ford, 1993; Caudill et al., 1995; Mester,

[3] The literature on productivity analysis provides strong evidence against use of the two-step estimation procedure because it provides biased estimates (Huang and Liu, 1994; Battese and Coelli, 1995; Wang and Schmidt, 2002).