Efficiency under quantile regression: What is the relationship with risk in the EU banking industry?

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ABSTRACT

This study estimates cost efficiency under a quantile regression framework. Our purpose is to investigate whether cost efficiency differs across quantiles of the conditional distribution. Efficiency scores are derived using the distribution-free approach. Results show that for higher conditional distributions, efficiency scores are lower. In a second stage analysis, we examine the relationship between efficiency and risk, measured as distance to default. Cross section regressions show that the higher the risk, the lower the level of efficiency. The magnitude and the significance of the coefficient of the distance to default increases for conditional distributions associated with lower levels of efficiency.

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1. Introduction

The efficiency of the European banking industry has attracted particular research attention, as evidenced by its long tradition in the literature (i.e., Allen & Rai 1996; Casu & Molyneux, 2003; De Guevara & Maudos, 2002; Lozano-Vivas, Pastor, & Hasan, 2001; Maudos, Pastor, Perez, & Quesada, 2002; Vander Vennet, 2002). One of the main findings in the majority of studies in this area is the existence of significant differences in the efficiency performance not only across banks, but also across banking systems (i.e., Barros, Ferreira, & Williams, 2007). These differences are present even though competition has intensified over the last years and despite enhanced financial integration in the EU (ECB, 2010; Goddard, Molyneux, Wilson, & Tavakoli, 2007). Prompted by these findings and in order to shed more light on this issue and to address the significant heterogeneity observed across banks, we depart from previous literature and employ the quantile regression analysis, proposed by Koenker and Bassett (1978) to estimate bank efficiency. The use of quantile regression analysis to estimate banks' cost

function,[1] allows us to derive different parameter estimates of the cost function for various quantiles of the conditional distribution and as a result different efficiency scores.

In particular, quantile regression relaxes one of the fundamental conditions of the OLS and permits the estimation of various quantile functions, helping to examine in particular the tail behaviors of that distribution.[2] This is particularly relevant in the context of bank efficiency, since the quantile analysis does not depend on any assumption regarding the conditional distribution of bank efficiency scores, which moreover is difficult to determine to a standard shape such as an asymmetric, fat-tailed, or truncated distribution. As a result the quantile analysis departs from conditional-mean models, as it allows for bank efficiency heterogeneity. Therefore, it is capable of providing a complete statistical analysis of the underlying diversity of stochastic relationships

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[1] This type of analysis entails the estimation of conditional quantile functions (see Koenker & Hallock, 2000). In this type of regression models quantiles of the conditional distribution of the dependent variable are expressed as functions of observed covariates. Quantile regression analysis has recently gained attention in the financial literature, and particularly in the field of empirical finance. Taylor (1999) provides quantile estimates for the distribution of multi-period returns, whilst Basset and Chen (2001) use quantile regression index models to characterize the diversity of mutual fund investment styles. For excellent reviews of the literature, see Koenker (2000) and Koenker and Hallock (2001).

[2] In general, each quantile regression characterizes a particular, center or tail, point of a conditional distribution. This approach estimates also the median (0.5th quantile) function as a special case, which approximates the mean function of the conditional distribution of banks' cost.

among stochastic variables by supplementing the estimation of conditional mean functions with an entire family of conditional quantile functions. The use of quantile regression techniques in the context of bank efficiency is rare, with the exception of Behr (2010),[3] and therefore comparative studies are limited. In any case, this is the first study to use quantile regression in a cross-country comparison of efficiency scores.

Departing from the standard conditional regression analysis, the main question this paper aims to answer, thus addressing a significant gap in the literature, is: what is the bank's i cost efficiency across different quantiles? To this end, we investigate whether cost efficiency differs across quantiles of the conditional distribution and whether there is a general trend that can describe the evolution of efficiency scores when estimated for different quantiles. In addition, we are also dealing with the question; does risk affect efficiency and how does this relationship evolve across quantiles? This interaction has become particularly important, in light also of recent adverse events in global financial markets. In particular, several shortcomings in the functioning of the global financial system and more specifically, significant incentive misalignments have greatly contributed, at the micro level, to the current financial turmoil (Caprio, Demirguc-Kunt, & Kane, 2008). In essence, these misaligned incentive structures have contributed to an understatement of true risk, generating mispricing of credit instruments. In light of this, the quantile regression analysis allows us to examine whether the underlying relationship between risk and performance changes across quantiles. This is an issue of particular importance as the recent crisis has demonstrated that the tales of the distribution, i.e. representing higher risk, may hold the key for understanding the underlying reasons for the malfunctions in the banking industry.

Several studies have in the past tried to investigate the appealing relationship between efficiency and risk. Berger and DeYoung (1997) provide an excellent analysis on the possible relationship between credit risk, efficiency and bank capital, offering four alternative hypotheses, i.e. the 'bad management', the 'bad luck', the 'skimping' and the 'moral hazard' hypotheses.[4] On theoretical grounds, evidence on this relationship can also be found in the charter theory of Keeley (1990), who argues that declines in bank charter values caused banks to increase default risk through increases in asset-risk and reductions in capital. Most researchers (i.e., Berger and DeYoung, 1997) have focused on the relationship between efficiency and credit risk, while a related strand of the literature has examined the relationship between efficiency and bank failure (Berger & Humphrey, 1992; Wheelock & Wilson, 1995) and found that failing banks tend to locate far from the efficiency frontier.

To empirically estimate cost efficiency, we follow Berger (1993) and employ the Distribution-free approach (DFA thereafter). As a measure of risk, we use banks' distance to default (DD thereafter) (see Merton, 1974). This measure has the advantage over traditional risk proxies based on accounting data, of using the forward-looking information incorporated into security prices. More specifically, it combines information about stock returns with leverage and volatility information, thus capturing the most important determinants of default risk.[5] Moreover, apart from risk, we also examine the relationship between efficiency and various bank specific and macroeconomic variables across quantiles.

A first glimpse at the results shows that efficiency scores exhibit marked diversity across quantiles, a finding which would go unnoticed in the classical efficiency estimations. In particular, we note that in higher

quantiles average cost efficiency is lower compared to that in lower quantiles. In addition, our analysis regarding the relationship between risk and efficiency suggests that there is a positive interrelation between bank efficiency and distance to default, especially in the case of lower conditional distributions. Moreover, the second-stage regression analysis reveals that the interaction between efficiency and various banking and macroeconomic variables varies substantially across quantiles. Two notable examples are the relationship between cost efficiency and bank concentration and the relationship between efficiency and credit risk.

The rest of the paper is organized as follows. Section 2 presents a brief review of the literature, Section 3 analyses the methodology, while Section 4 provides the description of the data. Section 5 discusses the empirical results, while conclusions are drawn in Section 6.

2. Literature review

Efficiency measures are accurate performance indicators of individual banks as well as of the banking industry as a whole, while they also entail information regarding the cost of financial intermediation. Regarding the relationship with risk, most researchers have focused on the relationship between efficiency and credit risk.

Berger and DeYoung (1997) provide an excellent analysis on the possible relationship between credit risk, efficiency and bank capital, offering four alternative hypotheses, i.e. the 'bad management', the 'bad luck', the 'skimping' and the 'moral hazard' hypotheses. Under the 'bad management' hypothesis, they argue that inefficient banks have also inadequate risk management systems and thus there is a positive relationship between efficiency and risk. Similarly, the 'bad luck' hypothesis suggests that due to exogenous negative shocks, increases in bank risk precede increases in their inefficiency. On the other hand, the 'skimping' hypothesis assumes that there is a trade-off between efficiency and risk in the short-term, due to moral hazard issues (as banks may appear to operate more efficiently in the short-term, if they devote less resources to manage their risks). Finally, the 'moral hazard' hypothesis suggests a negative relationship between bank capital and risk, on the basis that bank managers in less capitalized banks have incentives to take on higher risk. Berger and DeYoung (1997) employ Granger-causality techniques to test these four hypotheses and conclude that cost efficiency may be an important indicator of future problem loans and problem banks in the US. Williams (2004) undertakes a similar analysis for the European banking industry and finds that the 'bad management' hypothesis prevails for European banks. In addition, Podpiera and Weill (2008) address the question of the causality between non-performing loans and cost efficiency in a transition country (Czech Republic) and find evidence that deteriorations in cost efficiency precede increases in non-performing loans.

A related strand of the literature has examined the relationship between risk and efficiency by incorporating in the efficient frontier various aspects of risk. For instance, Kwan and Eisenbeis (1997) use a simultaneous equation framework to test hypotheses about the interrelationships between bank risk, capitalization, and operating efficiency and conclude that poorly performing banks are more vulnerable to risk-taking. Altunbas, Carbo, Gardener, and Molyneux (2007) apply a similar approach to Kwan and Eisenbeis (1997) to a sample of European banks and find no evidence of a positive relationship between inefficiency and bank risk-taking. Moreover, Mester (1996), and Hughes, Mester and Moon (2001) point out that failure to adequately account for risk can have a significant impact on relative efficiency scores. Berg, Førsund, and Jansen (1992) made the original observation and included nonperforming loans in a nonparametric study of bank production, whereas the concept to parametric estimations is applied in Hughes and Mester (1993). Some other studies use equity capital as a control for risk (e.g. Altunbas, Gardener, Molyneux, & Moore, 2001; Maudos et al., 2002), while others incorporate loan loss provisions in their efficiency estimation (e.g. Altunbas, Liu, Molyneux, & Seth, 2000; Pastor & Serrano, 2005).

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[3] Behr (2010) applies both the Stochastic Frontier Approach and the quantile regression approach to the German banking system in order to estimate cost efficiency scores and finds that efficient banks have production and cost elasticities which differ considerably from elasticities obtained from conditional mean functions and stochastic frontier functions.

[4] See Section 2 for a more detailed analysis.

[5] Although Chan-Lau and Sy (2006) have shown that due to the difference in the liabilities of financial institutions and non-financial firms the application of the distance-to-default to banks is not straightforward, other studies (i.e., Gropp, Vesala, & Vulpes, 2006) have shown that the distance to default is an appropriate measure of default risk of financial corporations, as it can predict well rating downgrades of banks in both developed and emerging countries.