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The risk of financial intermediaries

Manthos D. Delis [a], Iftekhar Hasan [b,*], Efthymios G. Tsionas [c]

[a] Finance Group, Surrey Business School, University of Surrey, Guildford GU2 7XH, UK
[b] Fordham University and Bank of Finland, 5 Columbus Circle, 11th Floor, New York, NY 10019, United States
[c] Economics Department, Lancaster University, Management School, Lancaster LA14YX, UK

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ABSTRACT

This paper reconsiders the formal estimation of bank risk using the variability of the profit function. In our model, point estimates of the variability of profits are derived from a model where this variability is endogenous to other bank characteristics, such as capital and liquidity. We estimate the new model on the entire panel of US banks, spanning the period 1985q1–2012q4. The findings show that bank risk was fairly stable up to 2001 and accelerated quickly thereafter up to 2007. We also establish that the risk of the relatively large banks and banks that failed in the subprime crisis is higher than the industry's average. Thus, we provide a new leading indicator, which is able to forecast future solvency problems of banks.

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1. Introduction

The financial crisis that erupted in 2007 turned the spotlight onto financial institutions and their risks. A fundamental and timely question is how the risk of a financial intermediary should be measured. This paper proposes a new method to estimate banks' risk using the variance of the profit function. The important element in our framework is that the variance of profits (risk) is allowed to be endogenous to a number of bank characteristics that determine bank profits and to profits themselves. In turn, these bank characteristics are also endogenous to risk and profits, yielding a system of equations where all the main bank managerial target variables are determined endogenously. This novelty is essential because existing measures do not allow for this type of simultaneity, which is inherent in the banking business.

We model risk as the variance of the profit function, where the variance enters as a multiplicative component of the error term. In this way, estimation of the profit function alone allows us to obtain point estimates of the variance of profits. We augment this framework with the implications of intermediation (banking) theory, which suggests that financial intermediaries make risky decisions simultaneously with the perception about expected profits and of the level of other bank characteristics, mainly capital and liquidity.[1]

To reiterate the endogeneity of bank risk, consider two banks with the same initial risk levels but different levels of capitalization or liquidity. In the next period the more liquid or more capitalized bank will be able to take on higher risk more easily, while the less liquid or less capitalized bank will have to lower its risk position. This simultaneity calls for a new model, where risk is jointly determined along with (i) other decisions made by the financial institutions (e.g., concerning their level of capitalization and/or liquidity) and (ii) expected profits. In other words, the variability of profits should be endogenous to other

* Corresponding author. Tel.: +1 646 312 8278; fax: +1 646 312 8290.
E-mail addresses: m.delis@surrey.ac.uk (M.D. Delis), ihasan@fordham.edu (I. Hasan), tsionas@aueb.gr (E.G. Tsionas).

[1] This is recognized by Kim and Santomero (1988), Shrieves and Dahl (1992), Diamond and Rajan (2000), Hughes et al. (2001), Dangl and Zechner (2004), Flannery and Rangan (2008), Freixas and Rochet (2008), Degryse et al. (2009), and Hughes and Mester (2011), among many others.

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important bank-level variables, which are in turn endogenous to profits and their variability. Thus, an important advantage of the approach presented here is that technology, risk, and bank decisions can be modeled simultaneously.

Our new method is general and can be applied to any firm. Here, we focus on financial institutions, and on banks in particular, due to a variety of reasons, including: the clear implications of banking theory concerning the endogeneity discussed above; the important developments in the banking sector before and after the subprime crisis; and the key role banks play in the managerial, real, and monetary economic spectrums. An important concern for our modeling choice is not to impose more stringent data requirements on the researcher, other than the usual bank-level data required for the estimation of the profit function of banks. We estimate our model using the full panel of US banks over the period 1985q1–2012q4. The estimation yields risk estimates at the bank-quarter level. The choice of the US banking sector allows an examination of the time path of bank risk that led to the banking crisis of the late 2000s.

The results indicate that the risk of the average in the U.S. banking sector was relatively stable up to 2001 and has gradually increased by more than 200% since then. This pattern is robust, irrespective of the functional form used to estimate the profit function and the variables included to tackle simultaneity. Thus, our measure captures the buildup of individual bank risk well before the eruption of financial turmoil in 2007, and this finding corresponds with perceptions about rising bank risk for a number of years before 2007. In contrast, a measure of risk obtained from a specification where the variance is not endogenous does not yield the same results.

We also show that bank risk is not the same across banks of different classes of size, and this is especially true after 2004–2005. Notably, all banks have risk levels very close to the industry's average until 2004. From then onward, the small and very small banks have lower risk than the average, while the large banks' risk surpasses the industry average after 2005. The very large banks also see their risk increasing considerably after 2002, yet they are less risky than the average until 2009. An alarming finding is that in the last three years of our sample, the riskiness of these systemically important banks is even higher than the industry's average. This stylized fact is in line with concerns that another bubble can emerge from the persistently high credit risk in the US banking sector.

Finally, we demonstrate that our measure predicts the higher risk undertaken by banks that became insolvent during the period after the crisis (from 2007 onward) relative to the industry's average. Our measure of bank risk therefore also qualifies as a new method to measure the probability of default and a leading indicator to forecast solvency problems of individual banks.

The rest of the paper proceeds as follows. Section 2 provides some theoretical considerations and empirical facts on the estimation of bank risk. Section 3 presents the formal econometric model that underlines our new method. Section 4 discusses the application of the new method to the US banking sector and presents the empirical findings. Section 5 concludes.

2. Bank risk measurement and empirical facts

To measure risk, the majority of the empirical banking literature uses accounting-based ratios that are related to credit and/or liquidity risk, and mainly include the ratio of (i) non-performing loans to total loans and (ii) loan-loss provisions to total loans, and (iii) the ratio of risk-weighted assets to total assets (Casu et al., 2006). These measures are *ex-post* informative about how risk evolves over time, but they do not seem to provide a good *ex ante* measure of bank risk.

Indeed, Fig. 1a and b shows that the bank-level average of the first two ratios reached an all-time low in the period just before the eruption of the subprime crisis, when bank risk was supposedly at its peak. In turn, Fig. 1c shows the equivalent trend in the risk-weighted assets ratio, which is the ratio used by regulators under the impact of Basel guidelines. The value of this ratio shows an increasing trend from 1986q4 to 1995q1; it then remains fairly stable until 2007, and drops sharply between 2008 and 2012. However, the risk-assets ratio has a number of interrelated shortcomings as a measure of risk. The most important of these shortcomings are that (i) risky assets are regulated, providing banks with incentives to underwrite these assets so as not to exceed the given threshold, and (ii) this ratio does not capture the perceived risk buildup that led to the financial crisis in 2007.

A related and more advanced strand of literature employs the variation in returns or profits as a more comprehensive risk measure. Mitchell (1982, 1986) is probably the first to note theoretically that the variance of returns or the variance of returns scaled by their mean (i.e., the coefficient of variation) is a valuable risk metric in banking, following directly from the theoretical considerations of Markowitz (1952) and Roy (1952). A recent line of empirical studies uses information from a fixed number of periods to calculate the variance in the return on assets, σ(ROA), or the coefficient of variation as a measure of bank risk (e.g., DeYoung and Rice, 2004; Stiroh, 2004; Stiroh and Rumble, 2006; Lepetit et al., 2008; Chiorazzo et al., 2008; Fang et al., 2011; Delis et al., 2012; Jiménez et al., 2013, 2014).

An extension of these measures has been put forth by Hannan and Hanweck (1988) and Boyd and Runkle (1993), who formalize the use of the *Z*-score of the probability of insolvency. Since insolvency is presumed to occur when current bank losses exhaust capital, estimates of the likelihood of insolvency can be obtained by noting that this likelihood is equivalent to the probability that ROA < −EA, where EA is the equity capital to assets ratio. Then $[E(\text{ROA}) + \text{EA}]/\sigma(\text{ROA})$ represents the number of standard deviations between the expected value of ROA and the negative values of ROA = −EA that yield insolvency.

One problem with the calculation of the *Z*-score, σ(ROA) or the coefficient of variation as measures of bank risk is that they use information from a fixed number of periods in the past (or from the whole sample period) to calculate the variance component and, therefore, do not capture the short-term nature of bank risk. This is especially true when only annual data is available to the researcher, which is often the case with bank-level data. Given the notorious short-term fluctuations of bank risk, it is important that we have a measure that captures the actual short-term fluctuations in bank profits, and not the fluctuations encompassing information from three years before or more. Yet, besides this problem, and perhaps more importantly, the *Z*-score, σ(ROA), and the coefficient of variation do not capture the endogeneity of bank risk to other bank characteristics.

Fig. 1d shows the evolution of the average *Z*-score = (ROA + EA)/σ(ROA), where ROA is the return on total bank assets and EA is the equity to assets ratio. Here, σ(ROA) at quarter t is calculated using ROA information from the past 12 quarters (data are from the Call Reports). The *Z*-score is fairly stable in the period 1995–2006; thus, it does not capture the increase in the probability of bank default prior to the crisis of 2007.

The equivalent graph for the coefficient of variation is even noisier and, for aesthetic quality, we smooth the line using a kernel regression and a bandwidth equal to six. We present the resulting average by bank in Fig. 1e, which shows that risk has accelerated from about 2005 onward. We should state, however, that this measure also seems to be affected by the time frame we use to construct

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