ARTICLE IN PRESS

REVFIN-0410; No of Pages 13

Review of Financial Economics xxx (2017) xxx–xxx

Contents lists available at ScienceDirect

Review of Financial Economics

journal homepage: www.elsevier.com/locate/rfe

An integrated macro-financial risk-based approach to the stressed capital requirement

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ARTICLE INFO

Article history:
Received 31 August 2016
Received in revised form 31 May 2017
Accepted 5 June 2017
Available online xxxx

JEL classification:
G21
G28
G32

Keywords:
Basel II & III Accords
Regime-switching models
Out-of-sample forecast
Conditional quantile forecast encompassing test
Prudential policies

ABSTRACT

In order to fulfill the stressed minimum capital requirement recently implemented by the Basel III Accord, this paper proposes a risk-based approach to integrate the change of macro-financial environments in which financial institutions operate into the modeling of the new required capital charge. Particularly, using a variety of regime-switching models, I characterize the stressed minimum capital requirement from high risk regimes which are associated with economic recessions and crises. The empirical results show that the proposed approach leads to capital charges 2–3 times higher than those estimated under Basel II Accord, so as to discourage excessive risk taking and hence stabilizing banks' balance sheets. Among competing models, the regime-switching $GJR-GARCH$ model spends the highest proportion of the out-of-sample time in the green zone, which results in the lowest penalties. The results are robust to subsamples.

1. Introduction

The Basel II Accord (Basel Committee on Banking Supervision (BCBS)(2006)) requires banks to preserve a minimum amount of regulatory capital to cover potential losses arising from their exposure to market risk, credit risk, and operational risk. The capital requirement for market risk is based upon estimates of Value-at-Risk (VaR), defined as the maximum loss on asset portfolios of a bank's positions given a holding period with a certain probability. However, the recent financial crisis undoubtedly demonstrated that existing capital regulation, in its design or implementation, was inadequate to prevent a panic in the financial sector, and governments around the world had to step in with emergency support to prevent a collapse.[1] Losses in most banks' trading books during the financial crisis have been significantly higher than the minimum capital requirement under the Basel II Accord Pillar 1 market risk rules (BCBS 2009, pp.1).

To address the market failures revealed by the crisis, the Basel Committee on Banking Supervision has introduced a number of fundamental reforms to strengthen global capital and liquidity rules with the goal of promoting a more resilient banking sector (BCBS 2009, 2010a, 2010b). The enhanced treatments (hereafter, Basel III Accord) include introducing a stressed Value-at-Risk ($sVaR$) capital requirement (BCBS 2009, 718(Lxxvi)), in addition to the non-stressed Value-at-Risk ($nVaR$) required by the Basel II Accord. This microprudential rule enhanced toward macroprudential policies is intended to generate a VaR measure on current portfolio if the relevant economic and market factors were experiencing a period of stress. The inputs for modeling $sVaR$ should be calibrated to historical data from a continuous 12-month period of significant financial stress relevant to the portfolio.

However, the amendments to the Basel II Accord do not prescribe specific methodologies for the new stressed capital requirement. Therefore, it opens the interest for individual banks to develop their own internal risk modeling approaches. Despite that a variety of internal risk models have recently been developed under the Basel

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[1] See, e.g., Hellwig (2010), Merrouche and Nier (2010), Demirguc-kunt, Detragiache, and Merrouche (2013), among others.

http://dx.doi.org/10.1016/j.rfe.2017.06.002
1058-3300/

Please cite this article as: X. Liu, An integrated macro-financial risk-based approach to the stressed capital requirement, Review of Financial Economics (2017), http://dx.doi.org/10.1016/j.rfe.2017.06.002

II regulation,[2] to the best of my knowledge, the up-to-date work to fulfill the new Basel III regulation is rare and lack success in capturing the changes of macro-financial environments in which financial institutions operate.[3]

The goal of this paper is to propose a risk-based approach to integrate macro-financial dynamics into the modeling of the new required capital charge by identifying and forecasting risk regimes. Specifically, this paper posits two risk regimes (high and low risk regimes). A high risk regime represents the risk level associated with the periods of recessions, crises, illiquidity and bankruptcy, etc. By contrast, a low risk state is associated with normal and good economic times, i.e., business expansions, asset market booms. This paper argues that the VaR value identified from a high risk regime, in which the distress probability of financial institutions is significantly higher than in a low risk regime, should be appropriately applied to a hypothetically stressed scenario required by the new Basel III capital rule.

In particular, I apply the regime-switching volatility and quantile autoregressive models, proposed by Bauwens, Preminger, and Rombouts (2010) and Liu (2016a) respectively, to identify and estimate risk regimes. Transition probabilities of regime switching are filtered from historical data in the sense of Hamilton (1994). In the context of this paper, the regime switching modeling approach is particularly appealing. First, a practical advantage is that the regime-switching approach has been supported by a vast literature of both macroeconomics and finance. The presence of business cycle regimes and structural breaks in capital requirements has been justified in e.g., Pederzoli and Torricelli (2005), Heid (2007), Jokipii and Milne (2008), Sjolander (2009) and Stolz and Wedow (2011). Second, risk regimes are endogenously identified from historical data for economic good and bad times. The intention of forward-looking capital requirement advocated by BCBS 2010b, pp.6, can thus be proceeded using forecasted transition probabilities and VaR values. Finally, a remarkable feature of using the regime switching framework to characterize $sVaR$ is that $nVaR$ and $sVaR$ can simultaneously be estimated within a unified econometric framework. This modeling feature is very attractive to account for the interaction between general and specific risks.

Empirically, this paper examines the proposed framework by using the U.S. financial market indexes as a bank's asset portfolios subject to market risk. The empirical results show that regime-switching models are able to produce lower minimum capital charges with smaller standard deviations than non-regime-switching models. Importantly, among competing models, the regime-switching GJR-GARCH (RSGJR) and regime-switching EGARCH (RSEGARCH) models spend the highest proportion of the time in a green zone and hence result in the lowest penalties. This result is also robust to subsamples. The proposed $sVaR$ estimated from high risk regimes provides the minimum capital requirement 2–3 times higher than that under the Basel II Accord regulation. This result helps fulfill the managerial goal of the Basel III Accord to stabilizing banks' balance sheets and discouraging excessive risk taking.

The current paper is organized as follows. Section 2 briefly describes the regulations of minimum capital requirement by Basel Accords. Section 3 introduces the regime-switching models used to estimate the stressed capital requirement. Section 4 describes data. Section 5 reports the estimation results, including estimated penalties and zones and minimum capital requirements. Section 6 evaluates the performance of out-of-sample VaR forecasts, including backtesting, encompassing test and regime forecastability test. Section 7 concludes this paper.

2. Minimum capital requirement

This section briefly introduces minimum capital requirement under the Basel II Accord and the additional capital recently required by the Basel III Accord. Penalty rules for the excessive number of VaR violations are also discussed.

2.1. Basel II Accord requirement

The Basel II Accord on banking regulations specifies Value-at-Risk (VaR) as the preferred measure of market risk for calculating minimum capital requirement. Let $\tau \in (0,1)$ denote a probability level. As defined in Adrian and Brunnermeier (2016) and Liu (2016b), the h-day holding period VaR, conditional on the past information set, $\mathcal{F}_{t-1}$, up to time $t-1$, is given by

$$Pr\left(R_t \leq VaR_t\left(h,\tau\right)|\mathcal{F}_{t-1}\right) = \tau$$

where R_t represents the portfolio return at time t. This definition makes clear that $VaR_t(h,\tau)$ corresponding to the τ100% conditional quantile of R_t.

As stated in BCBS 2006, 718(Lxxivi), the regulatory capital required to be held on day t is determined on a daily basis as the higher of (1) its previous day's $nVaR$ value ($nVaR_{t-1}(h,\tau)$) and (2) an average of the daily $nVaR$ values on the preceding sixty business days ($\overline{nVaR_{t,60}\left(h,\tau\right)}$) multiplied by a multiplication factor (m_c), that is[4]

$$MCR_t^{II} = max\left\{nVaR_{t-1}\left(h,\tau\right),\ m_c\overline{nVaR_{t,60}\left(h,\tau\right)}\right\} \tag{2.1}$$

where $nVaR_t(h,\tau)$ is the $nVaR$ estimate at day t for a holding period of h days at confidence level $\tau \in (0,1)$ and $\overline{nVaR_{t,60}\left(h,\tau\right)} = \frac{1}{60}\sum_{j=1}^{60} nVaR_{t-j}(h,\tau)$. MCR is increased by the multiplier $m_c = 3+k$, $k \in [0,1]$. m_c will be at minimum 3 for $k = 0$. The "plus", k, is a penalty imposed when the number of VaR exceedances (over the last 250 business days) becomes excessive. The number of VaR exceedances is defined and estimated as $\sum_{i=1}^{250} \mathbb{I}\left(R_{t-i} < VaR_{t-i}\right)$ where $\mathbb{I}[A]$ takes the value of 1 for the event A and otherwise 0.

The Basel II Accord states that banks are expected to ultimately move towards the application of a full 10-day price shock from markets. Hence, the VaR estimates are required for a holding period $h = 10$ days and an extreme confidence level $\tau = 1\%$.[5]

2.2. Additional capital requirement under Basel III Accord

One of the main reasons why the recent financial crisis becomes so severe is that the banking sectors of many countries had built up excessive on- and off-balance sheet leverages. This is accompanied by a gradual erosion of the level and quality of the capital base. The

[2] See, e.g., Kerkhof and Melenberg (2004), Ruthenberg and Landskroner (2008), Kerkhof, Melenberg, and Schumacher (2010), Wong (2010), A. Rossignolo, Fethi, and Shaban (2012), McAleer et al. (2009, 2013a; 2013b), Jimenez-Martin, McAleer, Perez-Amaral, and Santos (2013); Liu and Luger (2015a), among many others.

[3] Several alternative stress scenarios considered in Santos, Nogales, Ruiz, and Van Dijk (2012) and leptokurtic models estimated in A. F. Rossignolo, Fethi, and Shaban (2013) have respectively been used in the estimation of the $sVaR$.

[4] In order to distinguish from the stressed VaR ($sVaR$) under the Basel III Accord, the VaR under the Basel II Accord is denoted as $nVaR$.

[5] The regulation allows the 10-day VaR estimates to be computed from VaR estimates of shorter periods by using the square-root-of-time-rule, that is

$$VaR_t\left(10,1\%\right) = \sqrt{10/h}VaR_t\left(h,1\%\right) \tag{2.2}$$

for some $h < 10$ (see BCBS 2006, 718 (Lxxvi)). For instance, in empirical section, this paper estimates 1-day horizon VaR, which can be used to obtain 10-day VaR by $VaR_t\left(10,1\%\right) = \sqrt{10}VaR_t\left(1,1\%\right)$. Danielsson and Zigrand (2006) and Wang, Yen, and Cheng (2011) have discussed the use of the square-root-of-time-rule.

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