BASEL RISK WEIGHTS, ASSET CORRELATIONS AND BOOK-TO-MARKET EQUITY: *Evidence from Asian Countries*

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We examine the effect of firm book-to-market equity values (BE/ME) on asset correlations which play an important role in determining risk weights under the current Basel capital requirements. Using firms in China, Hong Kong, Japan, Korea, Singapore and Taiwan over a sample period from 1988 to 2013, we find that BE/ME has a negative effect on asset correlations. This suggests a role for BE/ME as an additional factor in determining asset correlations, and thus risk weights, also potentially reducing incentives for regulatory capital arbitrage.[1]

Based on the Basel II Accord finalised by the Basel Committee on Banking Supervision (BCBS 2006), asset correlation is a key parameter used in the internal ratings-based (IRB) approach to determine the minimum capital requirements for credit risk. Asset correlation measures the correlation between an obligor's asset returns and the common risk factor that reflects general economic conditions. A higher value indicates higher systematic risk which requires a bank to keep more capital, *ceteris paribus*. The BCBS (2006) approach estimates asset correlations as a positive function of firm size, and a negative function of firm default probability after adjustment for obligor type.

In this paper, we extend the study of Lee and Lin (2012) and Lee et al. (2013) by examining whether book-to-market equity values (BE/ME) affect the asset correlations of firms in China, Hong Kong, Japan, Korea, Singapore and Taiwan. We choose these countries as Australian-owned banks (especially the big four banks) have significantly increased their activity in Asia and these countries include both the second largest economy in the world and most developed economies in Asia. Our finding that obligors with higher (lower) BE/ME are related to lower (higher) asset correlation has important implications for the Basel capital requirements. First, BE/ME can improve the calibration of asset correlations that are initially determined by the common risk factor (i.e. the market factor), yielding a more accurate estimate of a bank's capital requirements. Incorporating BE/ME into Basel's Asymptotic Single Risk Factor (ASRF) framework may capture any additional systematic risk of an obligor that is currently missing in borrower types, default probability and firm size. Second, incorporating BE/ME as a systematic risk factor in estimates of asset correlations can also serve as an automatic mechanism to smooth the cyclical impact of the business cycle. As BE/ME tends to decrease during economic upturns, banks will be required to hold a higher capital requirement due to increasing asset correlations, potentially reducing their lending activities during good times. Failure to incorporate BE/ME into estimates of asset correlations may lead to inadequate specification in the IRB framework and to potential regulatory arbitrage by banks.[2]

The importance of BE/ME as another dimension of systematic risk for pricing equity has been documented by Fama and French (1992, 1993, and 1995) in the asset pricing literature. Indeed, BE/ME can be seen as an important proxy for systematic risk in estimating risk-adjusted returns. It follows that if BE/ME is a source of systematic risk on equity, it is also likely to be a source of systematic risk on assets.

A potential source of BE/ME on an obligor's systematic risk can be traced to its operating leverage, just as default probability is linked to a firm's financial leverage. Carlson et al. (2004) and Cooper (2006) show that high BE/ME firms, with more assets in place than growth options, tend to carry higher fixed assets relative to total firm value. If fixed production costs are proportional to irreversible capital invested, high BE/ME firms tend to have high operating leverage that leads to greater systematic risk. However, assuming production costs are variable, firms have options to lower costs by reducing capacity utilisation in response to falling demand. Aguerrevere (2009) shows that firms with high BE/ME may exhibit lower operating leverage, implying that BE/ME is negatively related to operating leverage. The aforementioned research indicates a potential linkage between BE/ME and operating leverage.

Our analysis yields the following results which improve the calibration of asset correlations and have important implications for the Basel capital requirements. First, after controlling for firm size, default probability and industry effects, firms with higher BE/ME are associated with lower asset correlations. This suggests a role for BE/ME as an additional conditional variable on asset correlations and risk weights. Second, asset correlations vary positively with firm size and negatively with firm default probability, as with the assumptions in the Basel approach. Our results are consistent with Lopez (2004) and Lee et al. (2011) but different from Dietsch and Petey (2004) and Lee et al. (2009) who report that asset correlations are higher on average for firms with higher default probability. Our evidence therefore supports the specifications of asset correlations in the ASRF approach in relation to firm size and default probability.

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Data and calibration methodology

Data for our sample firms in China (10,459 firm years), Hong Kong (10,337 firm years), Japan (16,596 firm years), Korea (8,993 firm years), Singapore (4,823 firm years) and Taiwan (7,477 firm years) are obtained from Datastream for the period from 1988 to 2013. All financial sector firms are excluded from the sample. We choose these sample countries because Australian-owned banks have significantly increased their activity in Asia to facilitate the large and growing trade and investment flows between Australia and this region.

According to the consolidated data in the International Banking Statistics (RBA 2013), the aggregate claims/exposures of all Australian-owned banks in Asia increased to $112 billion in December 2012, from $27 billion five years earlier. More specifically, the strong growth in Australian banks' Asian exposure focuses on four economies: China, Hong Kong, Japan and Singapore. We add Korea and Taiwan into our sample countries since they are another two important developed economies in Asia. We believe Australian bank activity in this region will expand over the longer term as trade and investment between Australia and Asia continues to grow. Since our research enhances the estimation of asset correlation and relates to credit risk of companies in these countries, the results should be of interest to Australian banks and investors.

To have sufficient observations to calculate the standard deviation of equity returns σ_E and equity beta β_E, we exclude firms with daily returns of less than 100 observations in each year. To calculate the standard deviation of asset returns, we also require firms to have five consecutive years of annual asset values. As our goal is to help banks assess possible credit losses, firms without debt are not relevant and are excluded from our sample. We estimate the asset correlation for each sample firm yearly using a final data sample which includes 58,685 firm-year observations, covering firms in 10 industrial sectors over a 26-year period. Specifically, we follow Lee et al. (2011) to estimate the correlation between the market rate of return and the implied rate of return on the firm's assets, using an approach derived from Merton (1974) and described in the Appendix. The summary statistics of relevant variables are presented in Table 1.

TABLE 1: Summary statistics of the sample firms

	Mean	Standard deviation	Minimum	Q1	Median	Q3	Maximum
Market value of assets ($millions)	1,118.13	3,003.24	10.90	97.69	257.15	740.74	59,656.46
Market value of equity ($millions)	533.82	1,374.90	5.17	43.85	125.60	382.55	15,658.69
Total liabilities ($millions)	595.25	2,007.58	1.34	35.84	102.20	331.9	47,387.08
Sales ($millions)	803.56	2,019.83	1.27	67.92	180.52	537.20	20,329.89
$Sigma_e$	0.4609	0.2235	0.0090	0.3108	0.4187	0.5625	4.8089
$Sigma_a$	0.2507	0.1769	0.0020	0.1323	0.2134	0.3223	4.7907
Book-to-market equity	1.1760	0.8884	0.2000	0.5261	0.9110	1.5453	4.9983
Default probability	0.0188	0.0584	0.0000	1.48E-07	2.22E-04	0.0083	0.9794
Asset correlations	0.1999	0.1752	7.37E-10	0.0488	0.1580	0.3145	0.9292

Note: This table presents the average values of market value of assets, market value of equity, total liabilities, sales, volatility of equity returns, volatility of asset returns, book-to-market, default probability, and asset correlations of sample firms from 1988 to 2013. All amounts are in US dollars.

Empirical results

Basel II assigns different weights for borrower types to estimate asset correlations. For instance, the asset correlation estimation for corporations (BCBS 2006) is:

$$\rho\left(PD\right) = 0.12\left(\frac{1-e^{-50*PD}}{1-e^{-50}}\right) + 0.24\left(1-\frac{1-e^{-50*PD}}{1-e^{-50}}\right) = 0.24 - 0.12\left(\frac{1-e^{-50*PD}}{1-e^{-50}}\right) \quad (1)$$

where PD is the probability of default. According to Equation 1, the regulatory asset correlation of regular firms ranges from 0.12 to 0.24 and there is a negative relationship between asset correlation and default probability. As shown in Table 1, our calibrated average asset correlation for all samples is 0.199, which is within the specified range of regulatory asset correlations.

We perform the following regression analysis to investigate whether BE/ME captures additional variations in asset correlations,

$$AC_{i,t} = \alpha + b_1 \ln(BE_{i,t} / ME_{i,t}) + b_2 PD_{i,t} + b_3 LnSales_{i,t} + \sum_{j=1}^{9} \gamma_j DI_j + \sum_{k=1}^{22} \delta_k DY_k + \sum_{l=1}^{5} \lambda_l DC_l + \varepsilon_{i,t} \quad (2)$$

where $AC_{i,t}$ is the asset correlation for i firm at time t; $\ln(BE_{i,t} / ME_{i,t})$ is the natural log of book equity to market equity; $PD_{i,t}$ is the default probability; $LnSale_{i,t}$ is the natural log of firm sales, as the proxy for firm size; DI_j is the industry dummy for industry j; DY_k is the dummy variable for year k; DC_l is the dummy variable for country l and $\varepsilon_{i,t}$ is the error term. For a robustness check on the regression results, we also apply the inverse logistic function, $ILnAC = Ln\left(AC/\left(1-AC\right)\right)$, to transform the asset correlation such that the dependent variable can vary beyond the restricted range of 0 to 1.

Table 2 presents the regression result. Model 1 in Panel A shows that BE/ME alone is significantly and negatively related to average asset correlations. Firms with higher BE/ME are associated with lower asset correlations. Adding firm default probability and firm size along with BE/ME in models 2 and 3 has little impact. BE/ME continues to explain average asset correlations that firm default probability and firm size fail to account for.

To check whether BE/ME is a proxy for industry effect, we add industry dummies as shown in model 5. Again, the significance of BE/ME effect is unaffected. These results are also robust to the inverse logistic function of asset correlations, $ILnAC = Ln\left(AC/\left(1-AC\right)\right)$, reported in Panel B. Consistent with Lee and Lin (2012), the results indicate that incorporating BE/ME as an additional explanator of asset correlations may improve estimation for asset correlations of firms.

Results in Table 2 also suggest that incorporating firm size does not alter the effect of firm default probability on asset correlations as the coefficient of firm default probability in model 4 is largely insensitive to the presence of firm size. This confirms that the impact of firm default probability and firm size on asset correlations is consistent with the specifications in the ASRF framework.

TABLE 2: Regression results of book-to-market equity, default probability, and size

Panel A: Dependent variable-AC	Model 1		Model 2		Model 3		Model 4		Model 5	
Intercept	0.390	***	0.382	***	0.198	***	0.198	***	0.208	***
	(16.65)		(16.39)		(8.86)		(8.86)		(9.27)	
BE/ME	-0.013	***	-0.011	***	-0.014	***	-0.012	***	-0.013	***
	(-18.38)		(-15.58)		(-19.82)		(-17.84)		(-19.15)	
PD			-0.259	***			-0.167	***	-0.175	***
			(-24.96)				(-16.87)		(-17.76)	
Ln(Sales)					0.030	***	0.029	***	0.028	***
					(81.07)		(78.74)		(76.21)	
Industry dummy									Yes	
Year and country dummies	Yes		Yes		Yes		Yes		Yes	
Adj. R^2	0.34		0.35		0.41		0.41		0.42	
Panel B: Dependent variable-Iln(AC)										
Intercept	-0.583	*	-0.696	**	-2.733	***	-2.741	***	-2.724	***
	(-1.97)		(-2.37)		(-9.57)		(-9.63)		(-9.50)	
BE/ME	-0.110	***	-0.082	***	-0.114	***	-0.093	***	-0.101	***
	(-12.11)		(-9.00)		(-13.01)		(-10.61)		(-11.40)	
PD			-3.652	***			-2.642	***	-2.721	***
			(-27.95)				(-20.86)		(-21.58)	
Ln(Sales)					0.332	***	0.320	***	0.315	***
					(71.00)		(68.33)		(66.42)	
Industry dummy									Yes	
Year and country dummies	Yes		Yes		Yes		Yes		Yes	
Adj. R^2	0.22		0.23		0.28		0.28		0.29	
N	58,685		58,685		58,685		58,685		58,685	

Note: This table presents the regression results of asset correlation on book-to-market equity, default probability, and firm size from 1988 to 2013. BE/ME is the natural log of book-to-market equity. PD is default probability. Ln(Sales), a proxy for firm size, is the natural log of sales. t-statistic is reported in parentheses.
*** denotes statistical significant at 1 per cent level.*

Conclusions

In the spirit of continuing improvements to the ASRF framework, we examine whether asset correlation is related to a firm's book-to-market equity value (BE/ME). We find that BE/ME, as a systematic risk related to a firm's operating leverage, captures variations in asset correlations. Our results have important implications for the Basel capital requirement. First, calibrating average asset correlations in the current Basel's ASRF framework for BE/ME may yield a more accurate estimate of asset correlations and thereby an improvement in bank regulatory capital adequacy requirements. More specifically, banks with obligors having a lower BE/ME should hold higher capital as they potentially exhibit higher systematic risk. In addition to different weights for obligors' size and default probability, different weights on asset correlations should also be imposed based on obligors' BE/ME. This approach can potentially reduce banks' incentives to engage in this aspect of regulatory capital arbitrage.

Second, incorporating BE/ME as a systematic risk factor in estimates of asset correlations can reduce the procyclical impact of capital requirement, one of the major regulatory issues in Basel III. As BE/ME tends to decrease during economic upturns, asset correlation will become higher, leading to a higher capital requirement. This automatic mechanism helps to smooth the cyclical impact of the business cycle as banks' lending activities will decrease due to a higher capital requirement. Finally, consistent with the current specification, our results also confirm that asset correlations are positively related to firm size and negatively related to default probability.

Notes

1. We would like to thank Kevin Davis and the anonymous referee for providing valuable comments on an earlier version of this paper. All errors are our own.

2. Regulatory arbitrage may occur as the risk of assets is not priced properly, thus providing incentives for banks to engage in more risky lending or hold more risky assets without the requirement for additional capital. For example, banks may generate more risky loans by obligors with a lower BE/ME relative to those with a higher BE/ME under current Basel capital requirement, which fails to consider BE/ME a systematic risk factor.

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APPENDIX

We follow Lee et al. (2011) to estimate asset correlation as follows:

$$\rho = \left(\frac{\beta_E E(t)\ \sigma_M}{V(t)\ \sigma_V\ N(-d_1\ (t,T))} \right)^2, \text{(A1)}$$

where $V(t)$ is the value of a firm's asset and $E(t)$ is firm's equity. $N(\cdot)$ is the cumulative normal density function; $d_1(t,T) = d_2(t,T) - \sigma_V(t,T)$

where $d_2(t,T) = \frac{\ln(\frac{B(t)}{V(t)}) + \frac{1}{2}\sigma_V^2(t,T)}{\sigma_V(t,T)}$ and $\sigma_V^2(t,T) = \sigma_V^2(T-t)$. β_E is the equity beta and σ_M is the standard deviation of the market returns.

Equation A1 shows that ρ can be estimated using well-known variables. However, since asset value and the standard deviation of the asset value are not observable, we need to estimate them before computing ρ. According to Merton (1974), a firm's equity, $E(t)$, can be viewed as a European call option,

$$E(t) = V(t)N(-d_1\ (t,T)) - B(t)N(-d_2\ (t,T)), \text{(A2)}$$

Applying Ito's Lemma,

$$\sigma_E = \frac{V(t)}{E(t)} N(-d_1\ (t,T))\sigma_V, \text{(A3)}$$

Equation A3 relates the standard deviation of equity returns, σ_E, to that of total asset returns, σ_V. Together with Equation A2, we can solve the market value of total assets, $V(t)$, and its standard deviation, σ_V. From Equation A2, $N(-d_2)$ is referred to the default probability of a firm. However, its measure relies on the risk-neutral assumption. To relax the assumption, we replace the risk-free interest rate with the instantaneous expected return on a firm's assets (μ_A) before calculating the default probabilities under an objective probability measure. We follow Lee et al. (2011) who use an option-based method to estimate μ_A.