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The Determinants of Bank Capital Ratios in a Developing Economy

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Abstract This paper reports new findings on the determinants of bank capital ratios. The results are from an unbalanced panel data set spanning eight years around the period of the 1997–1998 Asian financial crisis. Test results suggest a strong positive link between regulatory capital and bank management's risk-taking behaviour. The risk-based capital standards of the regulators did not have an influence on how regulatory capital is adjusted by low-capitalized banks, perhaps due to the well-documented banking fragility during the test period. Finally, bank capital decisions seem not to be driven by bank profitability, which finding is inconsistent with developed country literature that has for long stressed the importance of banks' earnings as driving capital ratios. Although the study focuses only on one developing economy, these findings may help to identify the correlates of bank capital ratios in both developed and developing economies since this topic has received scant attention of researchers. These findings are somewhat consistent with how banks engaging in risky lending across the world could have brought on the 2007–2008 banking liquidity and capital erosion crisis.

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1 Introduction

This paper examines, using panel data technique, how banking firms in a small developing economy (Malaysia) set their capital ratios and whether these capital decisions are associated with their risk-taking as well as changes in regulatory capital requirements. A verification of the association between bank capital regulations and management's capital decisions might provide some insights about the effectiveness of regulatory framework as it affects banking system operations in general as this nexus between bank capital/earnings/regulations is seldom researched although it is often stressed as a key policy issue in regulating banks in developing countries. This research issue is also relevant in the context of the 2007–08 worldwide banking liquidity crisis that was essentially brought on by a disconnect between bank earnings and capital provision on the back of the sub-prime crisis, although this paper does not cover the period of world financial crisis. Moreover, this issue has not yet been fully explored using developing country bank data: one exception is Song (1998), who concludes that the 1993 regulator-imposed higher capital requirements in Korea were generally effective. Similarly, Ghoshi et al. (2003) find that capital regulations of Indian public sector banks influenced bank management decisions and that these banks do not substitute low-risk government securities for high-risk loans, that is bank management appear to engage in risk-taking behaviour.

The main objective of this paper therefore is to investigate whether the *higher* capital requirements introduced by regulators during the test period, 1995–2002 did produce the desired increase in capital ratios to reduce risk (2002 is the year in which 55 deposit-taking institutions were merged into 10 institutions). An empirical verification of the association between capital regulations and bank management's capital decisions might provide some clue about the effectiveness of a regulatory framework of this one country's banking system operation. Malaysia adopted in 1989 the Basel Committee's Banking Supervision standard of 8% risk-weighted capital adequacy ratio (CAR). In 1996, Malaysia again followed the Basel Committee's recommendation and incorporated market risk into its CAR calculation. Then in 1999, it raised its capital adequacy requirement from 8% to 10%. The minimum capital funds for domestic banks were raised to RM 2 billion (US$ 605 million) by the end of 2000 after the 1997–1998 Asian financial crisis has passed off. These regulations were designed to create a safe and sound banking system by strengthening capital adequacy. Did it have the desired response from bank management? Externally, the regulators had imposed restrictions in October 1998 on short-term capital entry from outside the country, thus encouraging only longer-term flow of capital by introducing capital controls. The effect of these regulations are not investigated in this paper as capital adequacy ratio is more an internal regulatory framework given strong disincentives for commercial

banks to attract capital flows directly into commercial banks. There are other entities which attract foreign capital flow.

In this paper, the Basel 1988 risk-weighted capital adequacy ratio is used as a proxy for bank capital. For bank risk measurement, we use the newer Hannan & Hanweck (1988) risk index values as well as the non-performing loan ratio. This index expresses the level of risk in units of standard deviations of return on average assets (ROA). Similar to non-performing loans, this risk index also indicates default risk level since it approximates the book-value equity capital that a bank has available to absorb accounting losses. Thus, this allows us to investigate the link between bank capital and bank risk, so providing a newer approach to studying this neglected topic.

Over the twenty years prior to 1998, banks have enjoyed high earnings in this economy: this is generally true of many countries because of the good economic outlooks in the period from 1987–2001. Prior research in two economies finds bank earnings as one of the important determinants of bank capital ratios. Under the charter-value hypothesis, 'more efficient banks choose high equity capital ratios, all else equal, to protect the rents or franchise value associated with high efficiency from the possibility of liquidation' (Berger & Di Patti, 2003, p. 8). High profit and cost efficiency encourage bank managers to hold extra capital from earnings to protect against liquidation: alternatively regulations in many countries are designed to use high capital ratios as an indicator of bank quality. If Malaysia's bank management behave similarly to their counterparts in developed countries, a high charter value would provide self-regulatory incentives for banks to raise capital from earnings while simultaneously also helping to minimize their risk-taking as found in other studies such as Saunders & Wilson (2001) and Konishi & Yasuda (2004). It is therefore interesting to see how the management of banks in a *developing* country behave and whether bank capital decisions have the same nexus as reported in previous studies. Lastly, our findings may help to establish some benchmarks for future studies of bank capital decisions and to examine the usefulness of higher regulatory capital standards as imposed by regulators to promote bank safety.

The remainder of this paper is organised as follows. Section 2 provides the literature review while Section 3 presents the characteristics of the database and the methodology used. Section 4 provides the empirical results whilst the conclusions are presented in Section 5.

2 Literature Review on Bank Capital Determinants

Despite several studies on bank capital, the direction of the relationship between bank capital and bank risk remains ambiguous, and remains little researched. In an unregulated environment (no government guarantees or capital regulation), banks would still hold capital because markets require them to do so. Berger & Herring (1995) define this as the "market" capital requirement. This capital, among other things, acts as a cushion or buffer to absorb unexpected losses. When losses exceed this buffer, bank failure occurs. Since bank failure may prove contagious, bank capital should not be allowed to erode, thus it becomes a regulated item. Hence, the prevalence of regulator-required capital ratios in practice in all countries.

Bank regulators use capital regulations to ensure that the market capital is recognized as well as regulated to avoid this problem so as to constrain bank risk. Kahane (1977); Koehn & Santomero (1980); Kim & Santomero (1988) and Hovakimian & Kane (2000), however, argue that capital regulation has failed to control risk-shifting incentives. Koehn, Kim and Santomero use a mean-variance framework to illustrate that a strict bank capital standard is not a substitute for risk monitoring and controls. This is because a more stringent capital regulation may cause a utility maximizing bank owner-manager to increase asset risk. So bank owners are likely to treat leverage and risk as substitutes (Gennotte & Pyle 1991; and Rochet 1992) and simply increase asset risk when they are forced to reduce leverage (increase capital). At the same time, the rise in the cost of capital (profit margin falling as a result) due to raising new equity (with high transaction cost) may encourage banks to choose portfolios with even higher risk and expected returns (Berger *et al*., 1995). Greater risk taking may also expose them to credit crunch (Berger & Udell 1994; Peek & Rosengren, 1995)—a phenomenon well-documented in 2007–2008—leading to a fall in bank profitability (Chuiri et al. 2002). Thus, higher regulatory capital does not necessarily lower the probability of bank failure. The maintained hypothesis of the bank regulator is the reverse!

Other studies explain that factors such as government guarantees (the implicit and explicit deposit insurance, the too-big-to fail doctrine and lender of last resort support), earnings or franchise value and expected bankruptcy costs as affecting the level of capital in banking firms. Government guarantees, as in many countries (applies in Malaysia too), reduce the expected costs of bankruptcy as the default risk is transferred from the banks to the government: the world witnessed the effect of this during the year 2008 as central banks and treasuries moved in tandem to stem the bank liquidity problems across the world when so many countries moved to provide that guarantee for deposits and then followed up with massive injection of credits to banks to prevent failures (bankruptcies). This in turn reduces the incentives for depositors to monitor banks closely. At the same time, bank shareholders may exploit this reduced scrutiny by increasing bank leverage (that is, decreasing capital) and also earnings volatility because of increasing risk, and so shift the risk to the bank creditors and guarantors (Hovakimian et al. 2003). Hence, the benefits to society from government guarantees depend on how effectively bank regulators can control bank management's risk-shifting (Hovakimian et al. 2003) behaviour.

Divergences in risk preferences between owners and managers may also affect bank capital levels. According to Saunders et al. (1990), bank managers, as agents of the stockholders, may have an incentive to reduce the risk of bank failure below that desired by stockholders as the managers have more to lose personally, such as loss of high salary and other attractive benefits, should a bank fail. In this scenario, the 'managerial cost' associated with increases in either asset risk or leverage risk is the incremental disutility experienced by bank managers. Thus, managers of banks with high-risk asset portfolios may seek to offset this through low leverage (high capital) and vice versa, thus leading to a positive relationship between changes in risk and capital (Shrieves & Dahl 1992). In this case, an increase in loan portfolio risk will cause bank managers to raise more equity and/or reduce debt. The changes in bank capital therefore occur after changes in risk levels.

An increase in bank risk due to a sudden rise in the expected bankruptcy costs may force banks to raise their capital-asset ratios quickly to the new equilibrium levels.[1] The bankruptcy costs relate to transfer of bank ownership from the shareholders to the creditors (Berger *et al*., 1995). Orgler & Taggart (1993) states that optimal capital levels for banking firms may result from tradeoffs between the tax advantage of deposit financing and equity holdings. Bankruptcy costs, all other things being equal, reduce equilibrium bank leverage, that is, raises capital ratio. Since their expected bankruptcy costs reflect an increasing probability of failure, banks would likely raise their capital-to-asset ratios when their asset portfolio risk increases (Berger, 1995; Shrieves & Dahl 1992). Stock market collapse, weak home currency exchange rate and any unexpected rise in market interest rates are some market shocks that may increase the expected bankruptcy costs. The decision to raise more capital under this view is a response to these higher expected bankruptcy costs. Press reports in 2008 attest to this when world's leading banks of the likes of Citcorp, UBS, Merrill Lynch went cap in hand to the sovereign funds to inject capital.

Finally, a profitable bank will choose high equity capital ratios, all else being equal, to protect its charter value (Keeley 1990: and Demstez et al. 1996). Bank charter value refers to the present value of the future profits that a bank is expected to earn as a going concern (Demstez et al. 1996). The charter value hypothesis concurrently explains how a fall in earnings could also cause a bank to take greater risk.

3 Data, Variables and Methodology

3.1 Sample

There are three types of domestic banking institutions included in this study; commercial banks, finance companies and merchant banks. These are all subject to capital adequacy requirements as they are depository institutions. Annual data are obtained from the Fitch-IBCA's Bankscope database and from the company financial statements published by individual banks.

The banks were screened in two ways. First, we must have at least three years of data for each bank relating to variables to be used in regression. Likewise, all the accounting variables must fall within the range of −100% and +100% (Foster, 1986). We, therefore, exclude banks with extreme values of the reported data due to possible reporting errors in the Bankscope database. The final sample (initially 44) consists of annual observation obtained on 42 domestic financial institutions covering an 8-year period, 1995 to 2002. The sample size drops in 2001 and 2002 due to mergers and acquisitions. Therefore, in the two years 2001 and 2002 the data set consists of unbalanced panel data. The period 1995–2002 is chosen because prior to that, most domestic banks were family-owned or special-interest-controlled and/or unlisted and so their annual reports had less detailed information.

[1] The spectacular losses suffered by world's leading financial institutions in 2007–2008 witnessed a simultaneous scrambling to secure capital from willy-nilly anybody including the suspect sovereign funds. This is an attempt to re-establish bank capital to equilibrium level by CitiBank, Northern Rock, UBS, and so forth.

3.2 Methodology

In slightly modified form of models used in the past literature, we formulate a multivariate panel regression model. The model is premised on finding the level of bank capital of bank i in period t as a function of a range of bank specific variables as well as variables that measure regulatory pressure. Thus, the panel regression model is written as:

$$Y_{i,t} = \beta_0 + \beta_1 NPL_{i,t} + \beta_2 ZRISK_{i,t} + \beta_3 REGRWC_{i,t} + \beta_4 POST99_{i,t} + \beta_5 NIM_{i,t} + \beta_6 EQTL_{i,t} + \beta_7 LACSF_{i,t} + \beta_8 Y96_{i,tt} + \beta_9 SIZE_{i,t} + \varepsilon_{i,t} \quad (1)$$

where $Y_{i,t}$, capital ratio of bank i at time t; $NPL_{i,t}$, ratio of non-performing loans to gross loans of bank i at time t; $ZRISK_{i,t}$, the risk index of bank i at time t; $REGRWC_{i,t}$, a dummy variable: one denotes low capital bank and 0 otherwise; $POST99_{i,t}$, a dummy variable; one for 1999–2002 and zero for 1995–1998 period; $NIM_{i,t}$: net interest margin of bank i at time t; $EQTL_{i,t}$: ratio of total equity to total liabilities of bank i at time t; $LACSF_{i,t}$: ratio of total liquid asset to total deposit of bank i at time t; $Y96_{i,t}$: a dummy variable: one for the year 1996 and zero otherwise; $SIZE_{i,t}$: natural log of total assets of bank i at time t; and $\varepsilon_{i,t}$ is the error term.

The following section discusses each of these variables and their expected impact on bank capital as suggested in the theoretical literature.

3.2.1 Dependent Variables—CAR

Malaysian banks must adhere to two risk-based capital requirements: a 'tier 1 requirement' and a 'total capital requirement'. The former requires banks to maintain a minimum tier 1 capital to risk-weighted assets ratio of 4% while the latter requires a total risk-weighted capital ratio of 8%. The latter is the proxy for bank capital ratio used in this study.

Under the 1988 Basel Accord, bank capital is grouped under tier1 and tier2 capital. In our regression equation, the total risk-weighted capital adequacy ratio (CAR) acts as the dependent variable (Jacques & Nigro 1997; Ediz et al. 1998; De Bondt & Prast 2000; Rime 2001). CAR is defined according to the 1988 Basel Accord and is calculated as:

$$\text{CAR}(\%) = \frac{Tier1capitalI_t + Tier2capital}{Totalriskweightedassets} \times 100 \quad (2)$$

For banks, tier 1 capital consists primarily of shareholders' equity and other reserves, whereas tier 2 includes general loan loss provisions and subordinated debt. The denominator for the risk-weighted capital ratio is total risk-weighted assets. Total risk-weighted assets are the sum of the products of the book value of each asset and their corresponding risk weights. A risk weight is assigned according to the credit risk of the asset following the standard Basel 1 weightings of 0, 10, 20, 50 and 100%.

3.2.2 Explanatory Variables

Nine explanatory variables from the literature are chosen as the determinants of bank capital: five accounting-based variables (NPL, ZRISK, NIM, LACSF, EQTL and SIZE) and four dummy regulatory variables (REGRWC, POST99, and Y96). Their selection criteria and *a priori* expectations of expected relationship with bank capital are postulated from previous developed country bank studies (Jacques & Nigro 1997; De Bondt & Prast 2000; Konishi & Yasuda 2004).

Bank risk taking—NPL and ZRISK

Accounting-based models of bank risk are used here rather than market-based ones. This is because only sixteen of the 42 banks studied were listed on the then Kuala Lumpur Stock Exchange (KLSE now known as *Bursa* Malaysia). The first accounting risk measurement is the impaired non-performing loans (NPL). This reflects the quality of bank's loan portfolio[2] and is widely accepted in the literature as a measurement of credit or default risk. In this paper, the NPL ratio is the ringgit value of current year of "doubtful' loans to ringgit value of total loans (including the loan loss reserves) and high NPL signifies a risky bank.[3] Doubtful loans have repayments overdue for six months or more and have a very low recovery probability. Unlike in most other countries, the standard definition for bank NPL in this jurisdiction is different: a borrower makes no scheduled payments over a 180 day (6-month) period instead of the usual 90-day period in most countries.

An alternative accounting measure of risk is also employed. Variable ZRISK represents the Hannan & Hanweck (1988) accounting model of bank risk index.[4] The risk index ZRISK is calculated as follows:

$$\text{ZRISK}_{\text{i, t}} = \left[\text{ROA}_{\text{i, t}} + \text{EQTA}_{\text{i, t}}\right] / S_{ROA} \tag{3}$$

where ROA equals to return on average assets, EQTA refers to the equity capital-to-asset ratio and S_{ROA} is the standard deviation of ROA. Return on average asset is equal to net income divided by average total assets. The total assets are averaged using the arithmetic mean of the values at the end of the year t and t − 1. We compute the S_{ROA} for each bank over the observed time period and we get the value of ZRISK based on a time series approach over five years.

[2] Shrieves & Dahl (1992) use non-performing assets and the ratio of risk-weighted assets to total assets. Ediz et al. (1998) employ the ratio of very risky assets over total risky assets to reflect the bank's risk exposure while Berger (1995) and Jacques & Nigro (1997) favor the ratio of risk-weighted assets to total assets based on the Basle Accord's risk weight framework. De Bondt & Prast (2000) use loan ratio, defined as loans divided by total assets

[3] Under the Bank Negara Malaysia (central bank) guidelines, all NPLs in their entirety must be classified under either one of the following categories: (a) substandard accounts—when interest or principal is in default for between 6 and 9 months; (b) doubtful accounts—when interest or principal is in default for between 9 and 12 months; or (c) bad accounts—when interest or principal is in default for 12 months or more.

[4] The risk index is later used by Eisenbeis & Kwast (1991), Sinkey & Nash (1993) and Nash & Sinkey (1997),

As the ROA provides an overview of the bank's performance, its standard deviation describes the volatility of bank earnings. The equity capital-to-total assets ratio, on the other hand, shows the amount of equity capital available to absorb unexpected losses. Thus, the index incorporates three standard elements of bank risk and measures how much the earnings can decline until the bank has a negative book value and so becomes insolvent (Nash & Sinkey 1997). A low ZRISK implies a riskier bank whereas a higher ZRISK implies a safer bank. So while a positive sign on NPL variable signifies a positive, a positive ZRISK variable indicates a negative relationship between capital and risk. Based on past studies, there is no clear *a priori* direction predicted for the two risk variables.

Management quality—NIM

Another important determinant of bank capital is management quality, proxied by the net interest margin (NIM). NIM is defined as the ratio of the net interest income to total earning assets. Net interest income equals interest income minus interest expense and the earning assets refer to total loans and investments. The 'charter value' hypothesis discussed in Sect. 2 predicts a positive relationship between bank earnings and bank capital. High profits also provide bank shareholders sufficient income to raise extra equity capital to protect against liquidation. In addition, increasing bank capital through retained earnings provides a positive market signal about the bank's value in the presence of asymmetric information (Rime 2001). On the other hand, one may view high profitability to mean a low probability of failure (Yu 2000). As a result, the high profit may cause bank management to reduce capital cushioning given that its failure risk is very low. Therefore, the coefficient of NIM can also have a negative sign.

Regulatory pressure—Y96, POST99 and REGRWC

For regulatory standards, we include two dummy variables Y96 and POST99 in our specifications.[5] Y96 is unity for observations in 1996 and zero otherwise to capture the capital adequacy ratio that was amended in 1996 to incorporate market risk. While a positive sign indicates that the new regulation is binding and effective, a negative sign indicates that the bank may perceive that the regulation as non-binding or its capital ratio is already significantly above the new minimum requirement.

Dummy variable POST99 is unity for observations in 1999 until 2002 and zero otherwise. There was an upsurge in central bank regulation in 1999 onward: a rise in the risk-weighted capital adequacy ratio to 10%; and an increase in the minimum capital funds for domestic banks to RM 2 billion by the end of 2000. As with variable Y96, a positive response will indicate that these stringent 1999–2002 regulatory standards had the desired outcome.

[5] Malaysia's central bank has been implementing new capital regulations and improving its prudential supervision since the late 1980s. The 1985–1986 crisis led to the implementation of several banking reforms. Through the BAFIA Act passed in 1989, it introduced the Basle Accord 8% risk-weighted capital adequacy ratio (RWCAR) for commercial banks and finance companies. Interest rates were liberalized in late 1989 and CAR was amended for market risk in 1996. Despite those reforms, another banking crisis occurred in 1997–1998 after the Asian financial crisis. Subsequently, a upsurge in BNM's supervisory activities ensued with the introduction of the new liquidity framework (NLF) and a massive restructuring of the banking industry between late 1999 and early 2002. The merger proposal led to the creation of ten large banking groups and hence, reduction in the number of domestic banks from 55 to 10 financial groups. These bank mergers were assumed to promote greater efficiency and stability through a small number of larger-capital-asset based banks.

Capital requirements create pressure on undercapitalized banks to maintain higher capital ratios. Following past studies, a dummy variable, REGRWC, is also included in the regression as a proxy for regulatory pressure. For example, Shrieves & Dahl (1992) use a total capital ratio of 7% as the benchmark while Ediz et al. (1998) and Rime (2001), among others, measure regulatory pressure using the 8 per cent minimum requirement. For developing countries, the 8% minimum requirement is insufficient to protect against bank failure (Song 1998). This study, therefore, compares the risk-weighted capital adequacy ratio (CAR) of each individual bank with the industry average: REGRWC is unity for banks with CAR less than the industry wide average calculated by the central bank, zero otherwise. The sign of this coefficient can be either positive or negative. A positive sign indicates that the low-capitalized banks are under greater regulatory pressure than their counterparts to raise their capital ratios. A negative sign shows that although their capital ratios are below the industry average, their capital is in excess of the regulatory minimum.

Bank size—SIZE

As bank size also influences the amount of bank capital: the natural log of total assets (SIZE) is included to capture size effects. According to the franchise value hypothesis, higher earnings leads to greater diversification, so to more investment opportunities and thus lowering the cost of capital, provide incentives for large banks to raise more equity capital to avoid taking extraordinary risk. On the other hand, the relative easy capital market access along with the government's past too-big-too-fail policy rescues may cause larger banks to hold relatively less capital. Large banks, therefore, may exhibit lower capital ratio than small banks. So the coefficient of SIZE can have either a positive or negative sign.

Bank liquidity and leverage—LACSF and EQTL

A liquid asset-to-total deposit ratio (LACSF) and total equity-to-total liabilities (EQTL) are also included to proxy bank liquidity and leverage respectively. A high EQTL signifies low leverage (low debt/liabilities) whereas a low EQTL denotes high leverage (high debts/liabilities). An increase in bank liquidity (high LACSF) may have a positive impact on the capital ratio through its effect on the changes in required rate of return on bank shares. As the proportion of funds invested in cash and cash equivalents increases, bank liquidity risk must decline. This lowers the liquidity premium on the required rate of return on bank shares (Angbazo 1997). This rate in turn may encourage banks to raise equity. On the other hand, this is also positively related to bank leverage given that the risk to equity holders increases with leverage. As this risk rises, so will the cost of equity capital. Thus, high-leveraged banks (low EQTL) may find raising new equity difficult and hence, hold less equity than low-leverage banks (high EQTL). We expect both LACSF and EQTL to show a positive sign.

4 Results

4.1 Descriptive Statistics

Table 1 exhibits the mean and pairwise *t*-statistics for the selected variables for low versus high capital banks. The 'low' and 'high' column headings refer to bank capital

Table 1 Mean and pairwise *t*-statistics for selected variables by groups: low-capitalized versus high capitalized bank[a]

	Low-capital	High-capital	*t*-statistics
Capital measures			
Risk-weighted capital (*CAR*)	10.4825	15.6293	11.332***
Tier-one capital ratio (*TIER*)	8.2594	13.4614	10.094***
Equity-to-total liabilities (*EQTL*)	6.9168	10.0443	7.241***
Risk measures			
Non-performing loans to total loans (*NPL*)	10.550	10.019	−0.325
Risk index[a] (*ZRISK*)	12.498	14.315	0.239
Net loans to total assets (*NLTA*)	64.633	56.469	−5.069***
Management Quality			
Net interest margin (*NIM*)	2.9683	3.0220	0.725
Return on average assets (*ROA*)	0.8512	0.3738	−1.977**
Cost to income ratio (*CIR*)	46.9577	38.0869	−3.374***
Liquidity measures			
Liquid assets to total deposits (*LACSF*)	23.376	25.666	0.012**
Size measures			
Log of total assets (*SIZE*)	15.986	15.478	−3.254***

***significant at 1 % level **significant at 5 % level *significant at 10 % level

[a] The risk index, ZRISK, refers to the accounting model of bank risk index developed and used by Hannan & Hanweck (1988). It is calculated as follows: $\text{ZRISK}_{i,t} = [\text{ROA}_{i,t} + \text{EQTA}_{i,t}]/S_{ROA}$ where ROA equals to return on average assets, EQTA refers to equity capital-to-asset ratio and S_{ROA} is the standard deviation of ROA. Return on average asset is equal to net income divided by average total assets. The total assets are averaged using the arithmetic mean of the value at the end of the year t and $t-1$

levels. Low capital banks are those with risk-weighted CARs below the industry average while high capital banks are those above it. This overall average is compiled from the Bank Negara Malaysia (BNM) *Monthly Statistical Bulletin*. Since the early 1990s, the yearly average CAR for the banking system ranged between 10.5% and 13.8%, significantly above the required 8%.

The capital measures show that low and high capital banks have a mean risk-weighted CAR ratio of 10.4825% and 15.6293% respectively. Over the post-financial-crisis 1999–2002 though, the average CAR was considerably higher: 11.154% for low capital banks; and 17.229% for high capital banks. Thus, the increase, after the 1997 crisis may be explained, amongst other things, by the BNM's mandating higher capital requirements.

Loan portfolio risk is proxied by nonperforming loan ratio (NPL), risk index scores (ZRISK) and net loans to total asset ratio (NLTA): high NPL and NLTA signifies the riskier bank while a high ZRISK denotes a safer bank. Table 1 shows that the mean NPLs and NLTA for low capital banks are higher than for high capital banks while the latter's average ZRISK score is higher. These ZRISK scores (14.315 per cent versus 12.498%) indicate that low capital banks are exposed to greater risk than high capital banks since low ZRISK scores depicts high risk.

The statistics in Table 1 suggest a negative relationship between capital and risk (this differs from our multiple regression estimates in Table 4 below).

Berger and DeYoung 1997 suggest that managers of thinly capitalized banks are less risk averse because the upside risk of low capitalization outweighs the downside

Table 2 Pooled-sample descriptive statistics of the selected dependent and explanatory non-dummy variables

Variable	Obs	Mean	Std. Dev.	Min	Max
CAR	256	13.880	4.215	3.58	30.18
EQTL	264	9.991	4.533	−5.005	29.29
NPL	259	10.060	12.236	−4.314	65.682
NIM	264	2.998	1.149	−0.224	7.067
LACSF	264	24.806	6.957	7.447	54.603
SIZE	264	15.655	1.207	12.539	8.583
ZRISK	264	13.767	11.677	−2.510	51.996

CAR Risk-weighted capital adequacy ratio
EQTL Ratio of total equity to total liabilities
NPL Ratio of impaired loans to gross loans
NIM Ratio of net interest income to total earning assets
LACSF Ratio of liquid assets to total deposits
SIZE Natural log of total assets
ZRISK Risk index

risk. These banks have relatively less capital to lose in the event of default. Therefore, the moral hazard hypothesis predicts that low bank capitalization will lead to greater risk taking (Horiuchi & Shimizu 2001; and William, 2003). Finally, low capital banks (10.4825), in general, are larger than high capital banks (15.6293). This indirectly reflects the inverse relationship between size and bank capital found in our regression estimates. The *t*-statistics authenticate our findings.

Tables 2 and 3 present the descriptive statistics and the pair-wise correlation matrix of the regression variables respectively. The correlations indicate CAR is significantly correlated with NPL (0.269) but has a very low correlation with ZRISK (0.015). Correlation coefficients among the explanatory variables are reasonably low and the majority are statistically insignificant.

4.2 Regression Estimates

Our regression model is estimated using panel data techniques in addition to pooled ordinary least squares methods.[6] The panel data model is written in matrix notation (Baltagi 1995):

$$Y_{it} = a + bX_{it} + u_{it}, \tag{4}$$

$$u_{it} = \mu\prime_{it} + \nu_{it} \tag{5}$$

where u_{it} is a random term which comprised of two components, μ'_{it} denotes the unobserved individual or firm-specific effects and ν_{it} denotes the remaining disturbance.

[6] Kennedy (1998) suggest that estimation of panel data 'allows us to control for individual heterogeneity, alleviate aggregation bias, improve efficiency by using data with more variability and less collinearity, estimate and test more complicated behavioral models, and examine adjustment dynamic' (page 231).

Table 3 The pairwise correlation matrix for dependent (CAR) and explanatory non-dummy variables

	CAR	NPL	NIM	LACSF	SIZE	ZRISK	EQTL
CAR	1						
NPL	0.2686	1					
	(0.000)						
NIM	−0.1341	−.3591	1				
	(0.0320)	(0.000)					
LACSF	0.1672	−.0036	−0.1485	1			
	(0.0074)	(0.9544)	(0.0157)				
SIZE	−0.2873	−0.1523	0.0698	−0.0801	1		
	(0.000)	(0.0141)	(.2588)	(0.1944)			
ZRISK	0.0147	−0.2972	0.2500	0.1189	0.3191	1	
	(0.8147)	(0.000)	(0.000	(0.0536)	(0.000)		
EQTL	0.6798	−0.0506	0.1320	0.0090	0.2081	0.3711	1
	(0.000)	(0.4178)	(0.0320)	0.8845)	(0.007)	(0.000)	

CAR: Risk-weighted capital adequacy ratio
NPL: Ratio of impaired loans to gross loans
NIM: Ratio of net interest income to total earning assets
LACSF: Ratio of liquid assets to total deposits
SIZE: The log of total assets
ZRISK: The risk index
EQTL: The ratio of equity to total liabilities
(): probability of correlation equal zero

Table 4 reports the regression results for the determinants of bank capital.[7] We employ both the Hausman specification test and Breusch-Pagan Lagrangian multiplier test for random effects to validate the exogeneity of the individual effects with the explanatory variables. Both tests failed to reject the null hypothesis that the unobserved individual heterogeneity is uncorrelated with the explanatory variable. This suggests that the firm-specific effects and other variables in the model are uncorrelated and so the random effects model is the better choice to run. The fixed effects approach is nevertheless performed as well due to its use in previous studies so as to yield comparable results. The fixed effects model is also considered an appropriate specification when focusing on a specific set of N firms and the inference is restricted to their behaviour (Baltagi 1995). For comparison purposes, the fixed-effects model uses the within regression and feasible general least squares, FGLS, estimators. The random-effects estimates from the pooled ordinary least squares procedure are reported as well.

The numbers in columns 1 and 2 in Table 4 illustrate the results for a pooled OLS regression and fixed effects (within) regression.[8]The fixed effects within estimator

[7] To ensure no serious multicollinearity problem, we regress each independent non-dummy variable with all the other independent non-dummy variables (Lewis-Beck, 1980; Kennedy 1998). None of the *R*-squared from these equations is near to 1.0. Besides, there is less a collinearity problem using panel data compared to time-series and cross-sections data (Hsiao 1986).

[8] The fixed effects model focuses on the within unit (bank), i.e. across time, variation in the dependent and independent variables. When computing the standard errors and variance-covariance estimates for pooled OLS and fixed effects models, the disturbances are, by default, assumed to be heteroskedasticity and contemporaneously correlated across panels (refer to the STATA8 manual).

Table 4 Determinants of capital ratio: Total regulatory capital equation

Explanatory Variables	Regression models			
	Pooled OLS (robust)	Fixed effects (within)	Fixed effects (FGLS)	Random effects (FGLS)
NPL	0.0609 (0.0143)***	0.0647 (0.0163)***	0.0416 (0.0096)***	0.0642 (0.0149)***
ZRISK	−0.0701 (0.0146)***	−0.0412 (0.0594)	−0.0551 (0.0367)	−0.0641 (0.0205)***
$REGRWC^a$	−0.252 (−9.40)***	−2.6290 (0.3647)***	−1.6575 (0.1879)***	−2.7308 (0.3394)***
$POST99^b$	0.9226 (0.3371)***	1.0589 (0.3954)***	0.9143 (0.1810)***	0.8611 (0.3467)**
$Y96^c$	−0.6789 (0.4362)	−0.1431 (0.4183)	0.0728 (0.1598)	−0.0738 (0.4082)
NIM	−0.2954 (0.1237)**	−0.4073 (0.2167)*	−0.1587 (0.1161)	−0.3161 (0.1591)**
LACSF	0.0791 (0.0236)***	0.0904 (0.0249)***	0.0626 (0.0144)***	0.0803 (0.0223)***
EQTL	0.5673 (0.0453)***	0.5856 (0.0753)***	0.6876 (0.0494)***	0.5862 (0.0476)***
SIZE	−0.0274 (0.1289)	−0.9572 (0.4860)**	−0.1661 (0.2724)	−0.0961 (0.1870)
Constant	8.4386 (2.2762)***	22.0545 (7.8411)***	8.3467 (4.3420)*	9.2109 (3.169)***
Wald chi2			1705.66	481.35
R-squared:	0.7102	0.6154		0.6080
Within		0.7298		0.8155
Between Overall		0.6692		0.7093

The dependent variable is the risk-weighted capital adequacy ratio (CAR). The explanatory variables include 2 risk variables (NPL and ZRISK), 3 dummy variables representing regulatory pressure (REGRWC, POST99 and Y96) and 4 bank specific factors (NIM, LACST, EQTL and SIZE). NPL refers to the non-performing loans ratio. ZRISK is the risk index which is the sum of return on average asset (ROA) and equity-to-total-asset ratio (EQTA) divided by the standard deviation of ROA. REGRWC denotes one for low capitalized banks and zero otherwise. POST 99 denotes one for period 1999–2002 and zero otherwise. The dummy variable Y96 refers to the year 1996. NIM and LACST are the net interest margin and the ratio of total liquid assets to total deposits respectively. EQTL is the ratio of total equity to total liabilities and finally, SIZE refers to the natural logarithm of total assets. Total number of observations is 253. Reported in parentheses are robust standard errors.*** significant at 1% level ** significant at 5% level * significant at 10% level

focuses on the within unit (bank), i.e. across time, variation in the dependent and independent variables. As our tests point to a heteroskedasticity problem,[9] both models are run using the FGLS procedure to estimate the parameters. Only the results from the fixed effects model with FGLS estimators (column 3) are reported in this paper.

Finally, in column 4 of Table 4 are included the results for the random effects model.[10] This random effects model is also estimated using FGLS which allows estimation in the presence of autocorrelation within panels and cross-sectional correlation and/or heteroskedasticity across panels. The FGLS estimators are considered to be consistent and efficient (Baltagi 1995; Greene 2000).

High non-performing loans or impaired loans (NPL) are commonly associated with high risk and poor management (Barrios and Blanco, 2003). All models show the variable NPL is statistically significant at the 0.01 level, and has a positive sign. The results are similar when loan loss provisions were used instead. In contrast to NPL,

[9] The test on the autocorrelation problem shows negative i.e. no autocorrelated errors. The result is expected since the time series covered is only from minimum 3 years to maximum 8 years.

[10] Random effects FGLS estimator estimates the error variance-covariance matrix assuming that the errors follows a panel-specific autoregressive process and the variance of the error is allowed to be different across units (heteroskedastic) (Baltagi 1995).

the variable ZRISK is insignificant for the two fixed effects models (see columns 2 and 3) and the sign is consistently negative for all four models. The positive NPL and negative ZRISK would suggest we reject the null hypothesis that bank capital and risk-taking are unrelated. Instead the alternative hypothesis of a strong positive association between the two is found. This may be due to the unintended consequences of capital regulations and/or the shareholders' and managers' risk aversion (Shrieves & Dahl 1992) and/or the bankruptcy costs hypothesis (Berger, 1995). With respect to the banks in this study, the pressure to conform to the high risk-based capital standards may have caused them to increase their portfolio risk. So the results illustrate the unintended consequences of high capital ratios on bank behaviour.

In this study, three regulatory pressure variables, denoted by Y96, POST 99 and REGRWC, illustrate how the banks react to specific capital regulatory constraints. Y96 represents the 1996 implementation of market risk in the CAR and POST99 denotes the regulatory changes over 1999–2002. Y96 is statistically insignificant suggesting the market risk addition did not influence bank behaviour. In contrast, the high regulatory standards over 1999–2002 (variable POST99) have a positive influence on domestic bank capital adequacy ratios. All models show POST99 to be statistically significant at the 0.05 level or better and with a positive coefficient.

Based on *a priori* reasoning, there should be less regulatory pressure on banks to adjust their capital ratios during good times compared to bad times (De Bondt & Prast 2000; and Borio et al. 2001) The economy was booming in 1996 (Bank Negara, 1999) and this may have also contributed to banks' poor response. The banks may have also perceived the 1996 regulation as no different from previous guidelines as not binding. In contrast, the poor financial market conditions during and after the 1997 crisis placed greater pressure on domestic banks to conform to the new regulations since share market condition would make shareholder capital expensive to raise.

The third regulatory pressure variable REGRWC (one indicates low-capitalized banks and 0 otherwise) is consistently significant at the 0.01 level with a negative coefficient. This means that the high capital regulatory standards may have caused the low capital banks to reduce their risk-weighted capital adequacy ratio. This is not as odd as it may first seem. Even though their capital ratios were below the industry average, most "low capital" banks held capital in excess of the regulatory minimum. So the increased capital ratios over 1995–2002 might reflect the high capital decisions of banks to improve their capital ratios. This is consistent with Haubrich & Wachtel (1993) and Jacques & Nigro (1997) but is inconsistent with Shrieves & Dahl (1992). The last suggest that the regulatory influence is mainly on banks with relatively low capital. Jacques & Nigro (1997) explain that "banks with capital ratios significantly above the minimum requirement experienced larger increases in their capital ratios than did banks only marginally above the risk based threshold" (page 543). This can also be explained by the fact that the average size of the low capital banks is larger than the high capital ones (refer to Table 3) and larger banks tend to hold lower capital ratios than smaller banks as evident from the coefficient on SIZE.

Column 2 of Table 4 shows that SIZE is significant at the 0.05 level and the effect is negative suggesting an inverse relationship between size and capital. So, large banks face less pressure to raise capital than small banks. Or it may be that this pressure is less effective (Jacques and Nigro, 1998). However, since the fixed effects feasible GLS

as well as random effects model show the size variable is insignificant, bank size is seemingly not a determinant of bank capital in this country. This is inconsistent with the studies of banks in developed countries (Shrieves & Dahl 1992; Ediz et al. 1998; Jacques and Nigro, 1998; and Rime 2001).

On the relationship between bank capital and earnings, columns 1, 2 and 4 suggest that earnings have some influence on banks' capital ratios. In addition, NIM has a negative coefficient, which is inconsistent with the past empirical findings on the US, European and Japanese banks. Applying other measures of earnings (i.e. return on average equity and cost-to-income ratio) does not change the results. These findings contradict the view that a high earnings/franchise value provides bank managers easy access to equity capital and self-regulatory incentives to minimize risk taking (Cebenoyan et al. 1999: and Saunders & Wilson 2001). So, a bank may view high profitability as a sign of low probability of failure (Yu 2000). Indeed, high earnings may cause bank management to reduce capital cushioning accordingly. However, the fixed effects GLS estimator model (column 3) shows NIM is insignificant. So bank earnings are seemingly not an important determinant of bank capital for Malaysian banks. This is an important finding against self-regulatory capacity of banks in developing context.

On the other hand, bank liquidity and leverage do have a positive impact on bank capital as hypothesized. The variable LACSF and EQTL have the expected positive sign and are significant at 0.01 level in all four models. The positive sign of EQTL indicates a negative relationship between bank leverage and the risk-weighted capital adequacy ratio. Since the risk premium for high-leveraged banks (low EQTL) is higher than low-leveraged banks (high EQTL), the latter is expected to hold less equity capital. Although the level of liquidity is important, its impact on the total capital adequacy ratio is marginal. The coefficient of LACSTF shows that a one unit increase in bank liquidity gives rise to only a 0.07 unit rise in bank capital.

5 Conclusions

This study was motivated to find the determinants of bank capital ratios in a small middle-income developing economy's banking institutions covering a crisis prone period, which is the best period to study risk-taking behaviour. Two risk variables namely non-performing loans and risk index show a positive association between bank capital and risk-taking. This finding specifically rejects the null hypothesis: bank capital and risk are related suggesting that risk-taking behaviour of banks is the higher with increasing capital ratios. Banks which voluntarily reduced their debt-to-asset ratio (reduction in leverage), perhaps as a response to a higher capital requirement, will achieve their desired total risk by increasing their asset risk (a result consistent with Shrieves and Dahl, 1995). So when forced to raise their capital ratios, banks may have treated leverage and asset risk as substitutes, as observed in this study as well.

On the effectiveness of the capital regulations, the panel data estimates suggest that the high capital requirement rule mandated in 1996 in Malaysia was ineffective whereas those following the 1997 banking crisis and applied in the period 1999–2002 proved successful. Meanwhile, the negative sign of the coefficient for regulatory

pressure (REGRWC) implies that low capitalized banks responded by decreasing their capital ratios, as intended by the regulators. The high capital ratio regulations throughout the study period seem to have greater positive effects on the equity capital for the well-capitalized banks than on the low-capitalized ones, another important finding in the developing country context. The low-capitalized banks were, on average, much larger than the high-capitalized banks, so size is negatively related to capital ratios. Between large and small banks, the latter experienced greater pressure to increase its capital ratio (although holding high capital ratios) as discovered in past studies.

Interestingly, bank managers' capital decisions appear not to be seriously driven by profitability in this developing economy! Our finding suggests we accept the null hypothesis that bank capital and earnings are not strongly related. This is inconsistent with prior literature that has stressed the importance of bank earnings in capital decisions in the US (Berger, 1995; Saunders & Wilson 2001; and William, 2003). The coefficient is not significant. There is no clear empirical evidence to support the franchise value hypothesis for developing country banks since high earnings provide incentives for the banks in developed country to raise their capital, but not so in developing country. Perhaps, given the low level of quality differentiation of banks in developing countries during the test period, the concept of charter value is not that binding on pricing the banks.

This analysis raises three important questions for regulators. First, the evidence suggests that the high capital ratios do not always deter domestic banks from taking excessive risk. The majority of the domestic banks may therefore mitigate the effects of higher capital requirements by increasing their asset risk. Second, most of the rise in the capital ratios over 1999–2002 comes from the well-capitalized banks which, on average, are smaller in size than the much bigger low-capitalized banks. The capital requirements rule visibly persuaded only the small or well-capitalized banks to raise their capital ratios. For the riskier but capital constrained banks, the impact of regulation is less obvious or desirable. Thus, the effectiveness of capital regulation in promoting bank safety remains questionable for one section of the banking units despite the importance of the need to regulate this aspect in the absence of self-regulating capacity in developing countries. In addition, the weak relationship between bank capital and earnings reported here, to a certain degree, illustrates the current lack of self-regulatory incentives for adequate capital (for example to protect bank's franchise value) in banks.

Although we have not covered the 2003–2008 years in this paper, casual observations suggest that the Malaysian banks did not have serious exposure to the Worldwide banking crisis. In fact, the banks continued to have good liquidity, but were and still are unable to lend due to the post–2005 slowdown in economic activities. As is evident from casual observations relating to the period not covered by this paper, Malaysia is likely to recover from the current crisis less affected than are the cases of Korea and Thailand, two competing economies in the region. Thus, the regulatory oversights—in many forms starting with capital controls and regulated-mergers in this economy—have helped the banks to survive quite intact little affected by the world financial crisis.

This paper, however, has its limitations. The study covers the period 1995–2002. By using only the balance sheet ratios as capital and risk measures, the results may

not take into account market-driven factor of the economic conditions of the time. During the period, the economy experienced robust growth 1995–1996 and a sudden recession in second half of 1997 followed by banking recovery in 2001–2002 from the financial crisis. Therefore, it is interesting to see whether similar results are likely to prevail in the subsequent period after the merger of the 55 banks into 10 groups in late 2002. Our study was completed in 2004, so we did not have the data set at that time to extend the study to a later period.

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