Malaysian Bank Capital and Risk Profiles: Causality Tests

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Abstract

The structural relationships among bank capital and risk taking are empirically examined by utilising unit root tests and Granger causality tests using the time series data. The Granger causality test results are not very robust with respect to different types of banking institutions, risk variables (NPL and RWA) and time period. With merchant banks and finance companies aggregate data, there appears to be an absence of a Granger causality effect in the Malaysian banking sector. The evidence for Granger causality running from capital to risk or risk to capital appears to be statistically significant when the test is performed using the commercial bank aggregate data. Our results also show that there is no strong indication that using non-performing loans implies likelihood of finding a significant relationship. Finally, the evidence of lead-lag relationship between capital and risk is generally weak before the1997-98 banking crisis.

Keywords: Bank Risk, Capital Ratios, Risk-based Capital, Risk Index, Capital and Earnings.

JEL classification: G21, G28

1. Introduction

In relation to bank capital-risk relationship, two issues are normally raised: what kind of relationship is there between bank capital and risk? And, is it bank capital that "causes" the risk to change or is it the risk that changes bank capital? This paper focuses on the second issue by applying time series techniques as they are popularly used in analyzing the causal

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relationship between two or more variables. The findings on the causality or lead-lag relationships have strong implications for the interpretation of the link between bank capital and risk. Knowing the direction of the causality helps to determine whether the positive or negative relationship between bank capital and risk is due to capital causing risk (causation run from capital to risk) or risk causing capital (causation run from risk to capital).

Unlike past studies, we use, for the first time, Malaysian bank data to explore whether revisions in the bank capital ratio precede or follow revisions in bank risk by bank management or whether these changes are contemporaneous. So tests of either unidirectional or bidirectional (feedback) Granger causal relationship are conducted for each type of Malaysian banking institution: the commercial banks (CB), finance companies (FC) and merchant banks (MB). Appropriate tests, namely, unit-root test and Granger causality models are applied to discover whether the decision to change bank capital by the Malaysian banks occurs prior to or after changes in the bank risk level (Granger, 1969). So this paper, to some extent, provides a macro-analysis on capital ratios and risk profile of Malaysian banks for the years 1989 to 2003. The aggregate risk profile of domestic banking institutions and how it is linked with regulatory capital is empirically investigated and reported in this paper. Differences in the causality relationship before and after the 1997 Asian crisis are also examined.

The remainder of this paper is organised as follows. The literature review and the description of the methodology and data are covered in Section 2 and Section 3, respectively. The results are reported in Section 4 while Section 5 provides the conclusion as well as the limitations of this study.

2. Literature Review

There have been few empirical studies on the causality between bank capital and risk or assets. Some examples include Gunther and Moore (1993) and Corradi, Galeotti and Rovelli (1992). Gunther and Moore (1993) apply time series techniques to examine the long-run relationship between bank capital (book-value and market-value capital) and lending. They report that the level of bank lending is directly linked to bank capital and that an adverse shock to bank capital reduces bank lending in the long run. Meanwhile, Corradi, Galeotti and Rovelli (1992) investigate the relationship between bank reserves, deposits and loans. They find; (a) free reserves cointegrate with both deposits and loans; (b) in the short run the causal nexus runs from deposits to reserves and from deposits to loans; and (c) in the long run the causal nexus runs from deposits and loans to free reserves. Berger (1995), on the other hand, examines the causality between bank capital and earnings. He employs the Granger causality tests to determine whether the positive relationship between bank capital (capital-asset ratio) and earnings (after-tax return on equity) is due to capital causing earnings or earnings causing capital. He finds a positive causation in the Granger sense to run in both directions based on individual U.S. bank data for the 1980s.

When examining the relationship between bank capital and risk, some measurements of bank risk are incorporated in the analysis. These risk measures vary considerably across studies signifying no universally accepted definition. Indeed, determining bank's overall risk is a complex task given that risk can be defined in many ways and dimensions (Sinkey, 1978; Borio, Furfine and Lowe, 2001). For example, there are the distinctions between expected and unexpected losses, between relative and absolute risk, between idiosyncratic and systematic risk and between the risk of an individual bank and that of the overall banking system.[1] Risk can also be classified according to activities: market risk, economic environment changes, management and operations risks (Graham and Horner, 1988; Santoso, 2004). The following defines risk arising from a bank's operations or activities; credit risk, liquidity risk, market risk, diversification risk, interest rate risk and operational risk.

Risk in banking can first be subdivided into 'on-balance sheet' and 'off-balance sheet' risk. These on- and off-balance sheet items expose banks to several risks (Greenbaum and Thakor, 1995). First, there is the credit risk. This is the risk that its debtors will not pay their interest and loan repayments on time. Thus, every bank is exposed to unexpected losses incurred as a result of a customer's default. Liquidity risk, on the other hand, relates to the bank's liabilities. It is the risk associated with sudden withdrawal of funds by its creditors (depositors) at any time. It is the probability of a bank being unable to meet its short-term obligations such as the current and savings accounts. Banks with a high credit and liquidity risk have a higher probability of failure (Shrieves and Dahl, 1992; Barrios and Blanco, 2003). By definition, credit risk is positively correlated with total loans while the liquidity risk is negatively related with liquid assets (cash and government securities and deposits). There is also confounding between liquidity and credit risk. A portfolio heavily invested in government securities typically has high liquidity but low default risk.

[1] Borio, Furfine and Lowe (2001) define risk in terms of expected and unexpected losses, absolute risk and relative risk besides idiosyncratic and systematic risk. Expected losses refer to the average or mean losses anticipated over a particular period, while 'unexpected losses' refer to measure of the dispersion, or degree of uncertainty that surround that outcome. Relative risk relates to the risk in a cross section of a particular financial instrument, portfolio or bank. Absolute risk refers to the specific value that the measure of risk takes at a particular point in time.

Both credit and liquidity risks reflect loan portfolio quality of the banks. Banks are also exposed to the risk of changes in market prices or market risk. This refers to the risk of losses in on- and off-balance sheet positions arising as a result of unexpected changes in market prices via market interest rates, exchange rates, equity and commodity prices (Greenbaum and Thakor, 1995; Sinkey, 2002). In portfolio theory, market risk refers to systematic risk that cannot be diversified away. Banks can lower their credit and market risks through diversification. Market risk, for instance, is reduced when banks hedge their portfolio risk through geographic and product diversification, or derivatives contracts. Banks that concentrate on a few large borrowers, long-term loans or one location (a county, town or country) are exposed to a greater probability of failure. On the other hand, when banks diversify their operations geographically, banks are able to reduce the overall credit risk of their loan portfolio. Thus, another source of bank risk is a failure to diversify.

Financial institutions are also exposed to interest rate risk, which refers to the exposure of the bank's financial condition to the adverse movements in the interest rates. Changes in the interest rates affect a bank's earnings by changing its net interest income, interest-sensitive assets and liabilities as well as off-balance sheet instruments. This risk can be reduced by diversifying the durations of the fixed-income investments that are held at a given time. Finally, there is the operational risk. In recent years, there has been an accelerated increase in the regulators and banking industry's awareness of operational risk. The on-going transformation in the business of banking, risk management practices, supervisory approaches and financial markets contribute to operational risk's importance to banks and regulators (Basel Committee, 2003). Operational risk is defined as losses resulting from events that include: (a) internal fraud, (b) external fraud, (c) employment practices and workplace safety, (d) clients, products and business practices, (e) damage to physical assets, (f) business, disruption and system failures, and (g) execution, delivery and process management (Basel Committee, 2003).[2]

Bank capital on the other hand can be simply defined as the differences between bank assets and deposits (assuming deposits are the only bank liabilities). Using an accounting definition, bank capital refers to paid ordinary shares, surplus and undistributed profits. In an unregulated environment (absence of capital regulations), banks will still

[2] The Basel Committee recognizes that operational risk has a variety of meanings within the banking industry. Thus, the banks are allowed to choose their own definitions of operational risk. However, it is important that the definition considers the full range of material operational risks facing the bank and captures the most significant causes of severe operational losses (Basel Committee, 2003).

hold capital because the market requires them to do so. Berger, Herring and Szego (1995) define this as the market capital requirement i.e. "the capital ratio that maximizes the value of the bank in the absence of regulatory capital requirements (and all the regulatory mechanisms that are used to enforce them), but in the presence of the rest of the regulatory structure that protects the safety and soundness of banks" (page 395). Unregulated banks would in the long run move to this optimal capital structure as it maximizes shareholders value.[3] This optimal market capital ratio varies across banks and over time.

Given that the market may ignore the social costs of bank failure while the presence of government guarantees such as deposit insurance and too-big-too-fail doctrine reduce banks fear of bankruptcy, many countries require banks to hold a certain amount of capital. So capital requirements are imposed to ensure that a bank has sufficient capital to cover the major potential losses without causing bank runs or failures. The best known capital adequacy requirements are Basel Accord I and II, which set a minimum capital standard of 8 per cent for the ratio of bank capital to the bank's total risk adjusted assets (Basel Committee, 1999b).

3. Methodology

3.1. The Granger-Causality Test

The Granger-causality test performed in this study investigates whether revisions in bank capital ratio precede revisions in bank risk by bank management, or are contemporaneous. The following hypotheses are therefore tested:

> Hypothesis 1: Bank capital does Granger-cause bank's asset risk to change.
>
> Hypothesis 2: Bank asset risk does Granger-cause bank capital to change.

The test assumes that the information relevant to the prediction of the respective variables is contained solely in the time series data on these variables (Gujarati, 2002). There are three ways to perform this Granger-causality test. First, a simple Granger-causality test whereby there is a single equation with two variables (variables y and x) and their lags (autoregressive-distributed lag models). The hypothesis test whether the lags of the lagged variables x are equal to zero. A rejection of the hypothesis

[3] Santomero and Watson (1977) define the optimal capital structure as one in which the marginal returns from bank capital requirement equals the marginal cost of capitalization.

indicates that variable *x* causes variable *y*. Second, a multivariate causality test that includes more than two variables (variables *y*, *x* and *z*) in a single equation. When analysing the relationship between *y* and *x*, the influence of other variables such as variable *z* on the test results is considered. For example, variable *x* may have an effect on variable *y* via variables *z*.

This study chooses the bilateral Granger-causality test, estimated using the technique of vector autoregression (VAR). The VAR determines patterns in variables by estimating a system of equations in which each endogenous variable is explained by the past value of itself and all the other variables in the system. The current level of bank capital is, therefore, related to past values of itself as well as that of risk level, and postulates a similar behaviour for risk. Thus, the test involves estimating the following

$$CAPITAL_t = \sum_{t=1}^{n} \alpha_i RISK_{t-1} + \sum_{j=1}^{n} \beta_j CAPITAL_{t-j} + \mu_{1t} \quad (1)$$

$$RISK_t = \sum_{t=1}^{n} a_i RISK_{t-1} + \sum_{j=1}^{n} b_j CAPITAL_{t-j} + \mu_{1t} \quad (2)$$

regressions:
where:
C*APITAL*= the level of bank capital at time *t*
RISK = the level of bank risk at the period *t*
n = the number of lags, and

μ_{1t} = the error term.

The bank risk fails to Granger cause bank's capital ratio if, in the regression equation (1) above, the coefficients of lagged *RISK* are significantly zero i.e. $H_0: \sum \alpha_i = 0$. Similarly, the capital ratio fails to Granger cause bank risk if the coefficients of lagged *CAPITAL* in the regression equation (2) are significantly zero i.e. $H_0: \sum b_j = 0$.

Because the error terms are assumed to be serially uncorrelated with constant variance, each equation in the system can be estimated using ordinary-least squares (OLS) and the OLS estimates are consistent and asymptotically efficient (Enders, 1995). Therefore, the analysis of Granger-causality concentrates on testing the lagged coefficients of bank capital and risk variables in the capital-risk equation within a VAR-model. For equation (1), the null hypothesis is, that is, lagged *RISK* terms do not belong in the regression. In the case of equation (2), the null hypothesis is , that is, lagged *CAPITAL* terms do not belong in the regression. To test these hypotheses, the *F*-type test[4] is applied on the lags of the bank capital and risk variables. If the computed *F* value exceeds the critical *F* value at the chosen level of significance, the null hypothesis is rejected.

To ensure correct model specification and to avoid obtaining spurious results, the time series characteristics of the data are checked by testing for unit root. It is important that the time series variables must be stationary as the regression of a unit root variable against the other can lead to spurious results (Engler and Granger (1987).[5] In this study, the Augmented Dicky Fuller (ADF) test is performed.[6] The ADF requires running a regression of the first difference of the series against the series lagged once (X_{t-1}) and lagged difference terms (ΔX_{t-i}) such as:

$$\Delta X_t = \lambda_0 + \lambda_1 X_{t-1} + \lambda_j \sum_{j=1}^{m} \Delta X_{t-j} + \epsilon_t \qquad (3)$$

where Δ is the first difference operator, ε_t is a pure white noise error term, and *j* is the number of lagged first differenced term and is determined such that ε_t is approaching white noise. The null hypothesis is that X_t is non-stationary time series i.e. $H_0: \lambda_1 = 0$. The output of the ADF test consist of the 'τ (tau) statistics' on estimated coefficient of the lagged variable (λ_1) and critical values for the test of zero coefficient. If the estimated ADF statistic is larger than its critical value then the null is rejected suggesting that the series is stationary.

The number of lagged terms to be introduced in the causality tests is another important practical question as the specific lag length can significantly influence the test results (Enders, 1995; Gujarati, 2002). This paper employs both the Akaike (AIC) and Schwarz Information Criterion (SIC) to decide the number of lags. These two are the most commonly used selection criteria (Enders, 1995).[7] A model that gives the lowest values of AIC (or SIC) is chosen.

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4 Refer to Gujarati (2002) for the explanation on the steps involved in implementing the Granger causality test. The *F*-test is given as $F = \frac{(RSS_R = RSS_{UR})/m}{RSS_{UR}/(n-k)}$ which follows the *F* distribution with *m* and *(n-k)* df where *m* refers to the number of lagged of the endogenous variables and *k* is the number of parameters estimated in the unrestricted regression. Hence, *RSSR* is the restricted residual sum of squares while *RSSUR* is the unrestricted residual sum of the squares.

5 Stationary means that the variable's stochastic properties are invariant with respect to time i.e. the mean of *Yt*, its variance and its covariance with its lagged values do not depend on *t* (Kennedy, 1998).

6 The ADF addresses the problem of serial correlation of the error term by adding the lagged difference terms of the regressand (Gujarati, 2002).

7 In Eviews, the two equations are calculated as $AIC = -2l/T+2k/T$ and $SIC = -2l/T + kLog(T)/T$ where *l* is the value of the log of the likelihood function with the *k* parameters estimated using *T* observations.

3.2. Data and Sample Period

Given that Grange causality is a timely phenomenon, the interaction of economic or financial variables cannot work in short periods of a few months (Zestos and Tao, 2002). Quarterly data is, therefore, preferred over monthly data as the link between bank capital and risk is not instantaneous. So, this study uses the aggregate quarterly data of the risk weighted capital adequacy ratios (CAR), non-performing loan ratios (NPL) and risk weighted asset ratios (RWA) for the commercial banks, finance companies and merchant banks. The period of study covers from the fourth quarter of 1989 until the fourth quarter of 2003.

All the data has been provided by Bank Negara Malaysia. The data for the period December 1989 through December 1996 was obtained directly while that for the period January 1997 until December 2003 was obtained from various issues of Bank Negara Monthly and Quarterly Statistical Bulletin. All the commercial banks, finance companies and merchant banks are governed by the capital adequacy requirements of Basel I over this period.

In this study, the lead-lag relationships between capital and risk ratios before, during and after the 1997 Asian crisis are investigated. Thus, the quarterly time series data for the commercial banks, finance companies and merchant banks are divided into three sample sets:

(i) The whole sample period; fourth quarter of 1989 through the fourth quarter of 2003.
(ii) The period prior to the 1997 Asian crisis; fourth quarter of 1989 through the second quarter of 1997.
(iii) The period during and post-1997 Asian crisis; third quarter of 1997 through the fourth quarter of 2003.

The CAR is calculated according to the Basel I and the NPL ratio is the ratio of the ringgit value of current quarter of "doubtful" loans to ringgit value of total outstanding gross loans. The doubtful loans or non-performing loans are those overdue for three months or more. Besides the non-performing loans, the other risk variable in the Granger model, RWA, stands for the risk weighted asset ratio, which is equal to the total weighted assets divided by total assets. While NPL is an ex post performance measure of risk, the ratio of risk-weighted assets to total assets (RWA) is a true ex ante measure (Berger, 1995). RWA also captures the allocation of assets across risk categories and loan quality, and is normally less volatile than the NPL.

4. Empirical Results

To implement the Granger tests, equations (1) and (2) in Section 3 above are estimated (equation by equation) using the ordinary-least squares (OLS) method. The Granger F-statistic tests the null hypothesis that bank risk does not granger-cause (predict) capital in equation (1) while in equation (2) the null hypothesis is that bank capital does not granger-cause risk. The estimation requires the variables to be stationary. Hence, Table 1 shows the unit root test based on Augmented Dicky-Fuller (ADF) for CAR, NPL and RWA for commercial banks, finance companies and merchant banks.[8] The results indicate that all the variables are non-stationary in levels but stationary in the first-differences at the level of 5 percent significance or better. This means that they are all integrated of order 1 or I (1). The first difference of the time series has to be used in order to avoid the problem of non-stationary. With the first differences, however, the model captures or picks up only the short run effects or the short-run state of the relationship between bank capital and risk (Enders, 1995). This paper analyses, therefore, the short-run or disequilibrium state of the relationship between bank capital and risk.

Table 1. Tests for stationarity, 1989:4 to 2003:4

Variable (x_t)	ADF Test	
	Levels	1st diff.
Commercial banks		
Risk-weighted capital adequacy ratio	0.650	-2.841**
Non-performing loan to gross loans ratio	-2.354	-3.503***
Riske-weighted assets to total assets ratio	-2.142	-5.161***
Finance companies		
Risk-weighted capital adequacy ratio	-2.972	-7.199***
Non-performing loan to gross loans ratio	-2.928	-3.638***
Riske-weighted assets to total assets ratio	-2.897	-9.337***
Merchant banks		
Risk-weighted capital adequacy ratio	-0.234	-10.095***
Non-performing loan to gross loans ratio	-1.017	-6.353***
Riske-weighted assets to total assets ratio	-0.346	-7.088***

Note: *** and ** denote significant at 1 % and 5 % level respectively.

[8] Phillips-Peron test is also performed to check for stationary in the variables and the results also indicate that the risk-weighted capital adequacy ratio (CAR), non-performing loans ratio (NPL) and risk-weighted assets to total assets ratio are all non-stationary in levels but are first difference stationary.

The decisions on how many lagged terms to be included in the equations are guided by Akaike (AIC) and Schwarz Information Criterion (SIC). The model that gives the lowest values of these criteria is chosen. Tables 2 and 3 report the AIC and SIC values for different lag length model. The initial lag length is fixed at five on the basis that the lag between the two variables is most likely to fall within a year i.e. between 1 and 4 quarters.

In Table 2, the two endogenous variables are the risk-weighted capital adequacy ratio (CAR) and non-performing loan ratio (NPL). AIC suggests a lag length of 4 for the commercial banks and finance companies and 1 for the merchant banks. Based on SIC, the optimum lag length is 1 for commercial banks and finance companies and 0 for merchant banks.

Table 2. VAR Lag Order Selection Criteria
(Endogenous variables: The changes in CAR and NPL)

	Commercial banks		Finance companies		Merchant banks	
Lag	AIC	SIC	AIC	SIC	AIC	SIC
0	4.25	4.33	4.82	4.89	7.47	7.54*
1	3.98	4.20*	4.53	4.77*	7.47*	7.69
2	3.94	4.32	4.49	4.87	7.48	7.85
3	3.88	4.41	4.57	5.10	7.51	8.04
4	3.77*	4.45	4.49*	5.18	7.53	8.21
5	3.85	4.69	4.63	5.47	7.52	8.36

*indicates lag order selected by the criterion
AIC: Akaike information criterion
SIC: Schwarz information criterion

Table 3. VAR Lag Order Selection Criteria
(Endogenous variables: The changes in CAR and RWA)

	Commercial banks		Finance companies		Merchant banks	
Lag	AIC	SIC	AIC	SIC	AIC	SIC
0	5.16	5.24	4.35	4.43*	6.72	6.79
1	4.86*	5.09*	4.42	4.65	6.75	6.97*
2	4.99	5.37	4.32*	4.69	6.80*	7.18
3	5.03	5.56	4.40	4.93	6.89	7.42
4	5.13	5.81	4.49	5.17	6.93	7.62
5	5.14	5.97	4.59	5.42	6.95	7.78

*indicates lag order selected by the criterion
AIC: Akaike information criterion
SIC: Schwarz information criterion

Indeed, SIC has the tendency of choosing the lower lag length than the true ones (Hamilton, 1994). Hence, the lag length suggested by AIC is normally preferred over SIC.

In Table 3, the two endogenous variables are the risk-weighted capital adequacy ratio (CAR) and risk-weighted asset ratio (RWA). In the case of commercial banks, both AIC and SIC suggest a lag length of 1. Based on the AIC model, a lag length of 2 is recommended for finance companies and merchant banks. SIC, on the other hand, suggests a zero lag for finance companies and a lag length of 1 for merchant banks.

4.1. Direction of Causality

The results of the Granger-causality test are given in Table 4. In this table, equation (1) tests if *RISK* is causing *CAPITAL* and equation (2) tests if *CAPITAL* is causing *RISK*. In this case, *CAPITAL* stands for the total risk weighted capital adequacy ratio (*CAR*) and *RISK* refers to either the non-performing loans ratio (*NPL*) or the risk-weighted asset ratio (*RWA*). The null hypotheses of no causality are $\sum \alpha_i = 0$ and $\sum b_j = 0$ for equations (1) and (2), respectively. In the far left column, the directions of the causality are marked as CAR→NPL and CAR →RWA for causality running from capital to risk. Conversely, the tests for causality running from risk to capital are summarised as NPL →CAR and RWA→CAR.

The time series variables in equations (1) and (2) are lagged differences because of unit root problems. Moreover, tests for causality for lags 1-4 in every procedure are conducted rather than selecting a particular order of lags. In addition, Table 4 is divided in to three panels: Panel A presents the test results for the whole sample period, Panel B for pre-1997 crisis period and finally, Panel C for during and post-1997 Asian crisis. In each panel, the Granger results for commercial bank data, finance company data and merchant bank data are given. The table includes the computed F-values, the statistical significance level and the lag length of the respective model. In this study, test statistics at a level of 10 percent or better are considered as supporting Granger-causality. Hypothesis *1* states that the bank capital does Granger-cause bank's asset risk to change while Hypothesis *2* states the bank's asset risk does Granger-cause bank capital to change.

The findings reported in Table 4 depend on the sample period, the type of the banking institutions, and the number of lags utilised in the model.

Panel A: The Whole Sample

With NPL as a measurement of risk, the causality from capital to risk (CAR → NPL) is insignificant for all lag lengths for commercial banks and finance companies. For merchant banks, it is significant for lags 1 and 3 at the 10 per cent level. The causality from risk to capital (NPL→CAR) is significant only for the lag length of 1 and 4 at the 10 per cent level for the commercial banks but insignificant for the finance companies and merchant banks.

With RWA as a measurement of risk, the causality from capital to risk (CAR→RWA) is significant at the 10 per cent level for a lag length of 1 for merchant banks but significant for commercial bank data at lag length 1, 2 and 3 at the 10 per cent level or better. Again, however, it is insignificant for all the lags for finance companies. The direction of causality from risk to capital (RWA→CAR) is significant only for the lag length of 1 at the 10 % level for the commercial banks and finance companies.

Therefore, there is weak evidence of granger causality running from capital to risk in the period from 1989 to 2003 for finance companies and merchant banks. Changes in bank capital appear to have little or no direct effect on the level of risk taking as measured by NPL or RWA for finance companies and merchant banks. In contrast, there is evidence of bidirectional causality for commercial banks, particularly when RWA is used as a measurement of risk. The F-test on the lagged difference of CAR and RWA in Panel A indicates there is a short-run causality from capital to risk and risk to capital with a lag length of 1. Hence, the level of risk taking as measured by risk-weighted assets ratio of the commercial banks is shown to closely follow the bank capital as measured by the risk-weighted capital adequacy ratio.

Panel B: The Pre-1997 Asian Crisis

The causality from capital to risk (CAR→NPL) or risk to capital (NPL→CAR) is insignificant for all lag lengths of finance companies and merchant banks. With commercial bank data, the lead-lag relationship is detected for the period prior to 1997 with a lag length of 4 (see Table 4). The Granger F-value from CAR to NPL is significant at the 5 per cent level indicating CAR granger cause NPL. However, NPL does not granger cause CAR since the F value from NPL to CAR is insignificant. When the risk-weighted asset ratio (RWA) represents the level of bank risk, the causality from risk to capital is insignificant for all banks during the pre-1997 Asian crisis period.

Overall, the findings lack strong evidence of predictability of short-term changes in CAR from NPL or RWA for the period prior to the 1997 Asian crisis. Similarly, the findings fail to reject the null hypothesis that bank capital does not granger cause risk for commercial banks, finance companies and merchant banks.

Panel C: During and Post-1997 Asian Crisis

Panel C reports an improved bidirectional causality for the period during and after the 1997-banking crisis for commercial banks only when risk is measured by RWA. The joint F-test for Granger causality indicates that CAR granger causes RWA for the lag length of 1 and 3 at the 5 per cent level and RWA causes CAR for a lag length of 3 at the 5 per cent significant level. With the NPL as a measure of bank risk, the causality from capital to risk (CAR→ NPL) or risk to capital (NPL→ CAR) is insignificant for all lag lengths irrespective of the type of banking institutions. Practically no lead-lag relationships are detected for finance companies and merchant banks, even during and after the 1997-banking crisis.

The preceding discussion provides weak support for capital-risk causality. The evidence for Granger causality running from capital to risk or risk to capital is only pronounced when using the commercial bank aggregate data and then only for the period during and after the 1997 Asian crisis. There are two main explanations for the commercial bank group's stronger causality results. First, the commercial banks, on average, are relatively large institutions. As a result, the commercial banks play a greater role than the finance companies and merchant banks in the country's financial sector. Second, most of these commercial banks are listed on the stock exchange. So their capital decisions are dominated by both regulatory and market considerations. To some extent, the lack of feedback and contemporaneous causality among bank capital and risk variables for finance companies in particular, suggests that a change in bank capital ratio (CAR) does not appear to pressure their management to control risk. It is, therefore, possible that a rise in capital precipitated by regulators might not raise pressure on finance companies to reduce their risk exposure. This in turn may explain why the finance companies incurred huge losses and suffered high non-performing loans in the 1997-1998 banking crisis.

Lastly, the lead-lag relationship between capital and risk are investigated throughout the period 1989-2003. Malaysia officially adopted the risk-weighted capital adequacy requirements in 1989 but the requirements were not fully implemented until the end of 1992. The results for the sample period during and after the 1997 banking crisis in general are weak and, hence, fail to strongly reject the null hypothesis of no causality. This explains, to some extent, why the Malaysian regulators found it hard to use capital requirements to influence the level of bank risk taking during that period. In contrast, the results of the causality tests improve for the sample period during and after the 1997-98 banking crisis based on the commercial bank aggregate data. The crisis might have led to an increase in the predictability of capital from risk as well as risk from capital in the commercial banks. Hence, there is greater market discipline in Malaysian banking during and after the 1997-98 banking crisis. Obviously, banks are likely to react more to variations in capital and risk in times of crisis.

Table 4. Granger-Causality Tests

Sample Period 1: Quarter 4, 1989 – Quarter 4, 2003 (The whole sample period)
Sample Period 2: Quarter 4, 1989 – Quarter 2, 1997 (Pre-1997 crisis period)
Sample Period 3: Quarter 3, 1997 – Quarter 4, 2003 (During & Post-1997 crisis)

$$CAPITAL_t = \sum_{t=1}^{n} \alpha_i RISK_{t-1} + \sum_{j=1}^{n} \beta_j CAPITAL_{t-j} + \mu_{1t} \quad \text{(Equation 1)}$$

$$RISK_t = \sum_{t=1}^{n} a_i RISK_{t-1} + \sum_{j=1}^{n} b_j CAPITAL_{t-j} + \mu_{1t} \quad \text{(Equation 2)}$$

	Commercial banks				Finance companies				Merchant banks			
Panel A: The whole sample period, 1989-2003												
Lags:	1	2	3	4	1	2	3	4	1	2	3	4
CAR→NPL	0.29	0.04	1.41	1.99	1.83	0.87	0.49	0.67	3.26*	1.21	2.22*	2.85
NPL→CAR	3.65*	1.89	1.61	2.33*	0.29	0.08	0.41	1.09	0.37	0.85	0.63	0.56
CAR→RWA	5.58**	2.79*	2.58*	1.79	0.01	0.11	0.19	0.15	3.79*	2.34	1.31	1.80
RWA→CAR	3.45*	1.49	2.00	1.85	2.84**	2.13	1.73	1.42	1.34	1.01	1.62	1.28
Panel B: Pre-1997 crisis period, 1989-1997												
CAR→NPL	3.17	1.45	1.95	3.15**	0.64	0.38	0.07	0.06	0.04	1.09	3.33	2.87
NPL→CAR	0.82	0.73	1.61	0.44	1.24	1.40	1.37	0.94	0.57	1.15	0.71	1.29
CAR→RWA	0.59	1.34	2.57	0.69	0.94	0.46	0.67	1.66	4.31**	2.05	1.07	0.86
RWA→CAR	0.94	0.50	2.01	0.79	0.70	0.64	0.66	2.30	0.08	1.16	1.04	1.49
Panel C: During and post-1997 Asian crisis period, 1997-2003												
CAR→NPL	0.36	1.29	0,84	0.54	0.97	1.85	0.36	0.68	1.52	0.73	0.65	1.05
NPL→CAR	0.85	0.97	2.07	1.97	1.80	0.59	1.37	1.28	0.01	0.26	0.38	0.27
CAR→RWA	6.47**	3.02	3.72**	2.43	0.34	0.48	0.21	1.35	1.21	0.58	0.83	1.75
RWA→CAR	2.05	1.12	2.48**	1.46	2.06	1.66	1.66	0.23	0.97	0.19	0.95	0.65

**Significant at the 5 % level, * significant at the 10* level.

Equations 1 and 2 are Granger tests of causality. Equation1 tests if X is causing Y and equation 2 tests if Y is causing X. Y stands for total risk weighted capital adequacy ratio (CAR) and X refers to either the non-performing loans ratio (NPL) or the risk-weighted asset ratio (RWA). The null hypotheses of no causality are $\sum \alpha_i=0$ and $\sum a_j= 0$ for equations 1 and 2, respectively. The test for causality is based on an F-statistic.

5. Conclusions

Our results document evidence of causality relationship between bank capital and risk taking in each type of Malaysian banking institution: commercial banks, finance companies and merchant banks. For analytical purposes, the data has been divided into three sets: the whole sample period (1989-2003), the period prior to the 1997 Asian crisis (1989-1997) and the period during and post-1997 Asian crisis (1997-2003). The causality relationship is analysed based on the Granger tests. Preliminary tests for a unit root and the number of lag length are performed prior to the Granger causality tests.

The tests of Granger causality yield mixed results. First, there is a stronger case of Granger causality in the commercial banks than in finance companies and merchant banks. The results for commercial banks show that the changes in risk-weighted capital adequacy ratio (bank capital) and risk-weighted asset ratio (bank risk) are closely related and that causality is established in both directions. This implies that the changes in bank capital are tied directly to the changes in bank risk as measured by the risk-weighted assets ratio and vice versa. A short-run causality from capital to risk and risk to capital is observed, particularly during the whole sample period with a lag length of one. The evidence, however, is less clear when bank risk is represented by the ratio of non-performing loans.

Comparing the finance companies and merchant banks, the results for finance companies show a weaker case of Granger causality. All the three data sets for finance companies consistently show that bank capital[9] does not enter into a short-run relationship with bank risk taking. Thus, the results fail to reject the null hypothesis of no causality between bank capital and risk taking. The lack of feedback and contemporaneous causality between bank capital and risk taking for finance companies suggest that a change in bank capital ratio (risk) appears not to pressure their management to control risk (bank capital). Coincidentally, the finance companies were most badly hit by the recessions during the mid-1980s and the late 1990s. Conversely, the evidence for Granger causality running

[9] Please note that in Malaysia, banking institutions include commercial banks, finance companies and merchant banks. Please refer to Section 1.2 for more details.

from capital to risk or risk to capital appears to be statistically significant when the test is performed using the commercial bank aggregate data. Among the three groups, the commercial banks are the largest group of financial institutions and, thus, play the most active and important role in the country. Subsequently, their capital decisions are significantly dominated by both regulatory and market considerations as evident by a strong case of Granger causality for the commercial banks.

Lastly, practically no lead-lag relationships are discovered for the period prior to the 1997 Asian crisis. In general, the findings fail to reject the null hypothesis of no causality from capital to risk (Hypothesis 1) or risk to capital (Hypothesis 2). In contrast, the results indicate an increase of contemporaneous causality during and after the 1997-98 banking crisis based on the commercial bank aggregate data. This suggests that the crisis and higher capital requirement implemented during that sample period might have led to greater market discipline among the commercial banks. Their capital decisions seem to be linked more to their risk levels and vice versa after the crisis.

There is also no strong indication that using non-performing loans imply the likelihood of finding a significant relationship. Finally, the evidence of lead-lag relationship between capital and risk is generally weak before the 1997-98 banking crisis. The results of the causality tests improve for the sample period during and after the 1997-98 banking crisis, again for commercial banks only. This shows that, to some extent, the capital requirements introduced after the banking crisis were effective in influencing bank behaviour. Obviously, banks are likely to react more to variations in capital and risk in times of crisis.

Using the Granger causality test to examine the lead-lag relationships does have some weaknesses. As the first differences are used due to the unit root problems, the analysis only refers to the short-run relationship between bank capital and risk. Moreover, the test is sensitive to the number of lagged terms used in the model and it assumes that the underlying time series is stationary. The cointegration regression might be the better tool to use.[10] Future studies ought to include the cointegration technique to test for a long-run relationship between bank capital and risk taking as measured by the non-performing loans and risk-weighted asset ratios of the whole banking sector.

[10] In the early stage, we did make an attempt to use the cointegration regression but the results obtained were weak and unstable. Because of that, the findings reported here only focus on the regression results obtained from the Granger causality test.

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