Journal of Banking and Finance 73 (2016) 16–37

Contents lists available at ScienceDirect

Journal of Banking and Finance

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

The impact of non-interest income on bank risk in Australia

Barry Williams

Department of Banking and Finance, Monash Business School, Monash University, Victoria, Australia

ARTICLE INFO

Article history:
Received 23 September 2012
Accepted 24 July 2016
Available online 20 August 2016

JEL:
G21
G28

Keywords:
Bank risk
Non-interest risk
Interval value at risk

ABSTRACT

The relationship between bank revenue composition and bank risk in Australia is modeled using data drawn from Australian bank confidential regulatory returns. It is found that those banks with lower levels of non-interest income and higher revenue concentration are less risky, consistent with previous international evidence. Evidence is also found supportive of increased risk due to too-big-to-fail effects, with this risk increase being offset by a decline in large bank risk after the crisis of 2007–2008. Non-interest income is generally found to be risk increasing, but some types of non-interest income are risk reducing when bank specialization effects are considered. It is also found that the 2008 financial crisis changed some aspects of the relationship between bank risk and revenue composition.

1. Introduction

The importance of the twin issues of bank income diversification and bank risk have been highlighted by the Global Financial Crisis (GFC). The relevance of increased understanding of the factors that determine bank risk have been emphasized by the large costs imposed upon a number of stakeholders in the banking system by the negative outcomes of bank portfolio choice. Prior to the GFC, the impact of bank income diversification upon bank risk had attracted increased academic attention in response to regulatory changes, mainly in the United States. This was particularly in response to the introduction of the Gramm–Leach–Bliley Act which allowed bank holding companies to offer both commercial and investment banking. As discussed by DeYoung and Torna (2013) and Engle, et al. (2014) a number of commentators have blamed the GFC on increased non-traditional activity in the banking sector. An increase in emphasis of bank income upon non-interest income as opposed to the more traditional interest margin income resulted from both regulatory changes and changes in the nature of the banking system's competitive environment (Allen & Santomero, 2001). Furthermore, Brunnermeier et al. (2012) demonstrate that banks with higher non-interest income display higher levels of systemic risk. Due to all of these factors, the issue of the impact upon bank risk of income composition is of increased importance.

This paper extends the existing literature in a number of ways. By employing data drawn from the confidential prudential returns provided to the Australian Prudential Regulation Authority (APRA) by Australian banks, a more detailed analysis of bank revenue is possible, as compared to studies which employed data drawn from annual reports. Second, the Australian financial system did not experience any systematic bank failures that were a characteristic of the GFC in a number of other developed nations. Thus, by studying the Australian system over the period leading up to, including, and following the GFC, a number of insights may be drawn. Furthermore, non-US studies of the relationship between bank risk and bank revenue composition remain relatively sparse, and thus this study contributes to this segment of the literature. Finally, the issue of bank income and risk is considered from a number of perspectives, including risk measures based upon balance sheet data, market-based risk measures including marginal expected shortfall (Acharya, et al. 2012), market-based Value at Risk as well as bank-specific confidential internal estimates of Value at Risk resulting from exposure to market risk.

To date the body of evidence has found, contrary to conventional portfolio theory, that bank revenue diversification results in a worsening of bank risk-return trade-off. Studies such as Stiroh (2006) and DeYoung and Rice (2004) have documented that diversified banks in the United States experience a diversification discount. However, authors such as DeYoung and Torna (2013) and Engle et al. (2014) have presented evidence that bank non-interest income is not unambiguously risk increasing. These contrary findings increase the relevance of studying this issue from a number of perspectives in different financial systems.

This study finds that bank non-interest income is associated with increased bank revenue volatility and stock market tail risk (marginal expected shortfall, Acharya et al., 2012). It is also found that the channel via which non-interest income increases revenue

E-mail address: barry.williams@monash.edu

http://dx.doi.org/10.1016/j.jbankfin.2016.07.019
0378-4266/

volatility changed in the wake of the 2007–2008 financial crisis. Further, the existence of increased risk (both revenue volatility and marginal expected shortfall) is found for large banks. Increased size is accompanied with increased risk for the large banks, suggesting that the major banks have exceeded the maximum efficient scale in terms of risk. It is argued that the moral hazard effects associated with too-big-to-fail status explain this increased risk.[1] Offsetting this increased major bank risk due to too-big to-fail effects is evidence that major bank systemic risk declined after the financial crisis of 2007–2008. It is suggested that this decline could have been due to some combination of increased regulatory surveillance of large banks after the financial crisis and the introduction of a government guarantee of bank deposits in Australia in 2008. In contrast, for the smaller banks, increases in size is found to result in risk reduction benefits. Additionally, bank internal estimates of Value at Risk due to market risk are, unsurprisingly, found to be positively associated with investment banking as well as trading and investment activity.

The rest of this paper is structured as follows: the next section provides a more detailed review of the existing evidence to date. The third section provides the details of the data and methodology employed in this study. The fourth section presents and discusses the results, while the final section provides concluding comments and policy implications.

2. Literature review

The composition of bank revenue has been observed to increasingly emphasize non-interest income (Allen & Santomero, 2001; Laeven & Levine, 2007). One factor in this process has been the increased emphasis upon financial conglomerates providing one stop financial services (van Lelyveld & Knot, 2009). The process of disintermediation has seen banks face increased competition from other providers of financial services (shadow banks) (Lepitit et al. 2008a). Importantly, Brunnermeier et al. (2012) have found that banks with higher levels of non-interest income increase the systemic risk of the banking system.

The traditional arguments in favor of banks increasing the diversity of their revenues are sourced in mean-variance portfolio theory as well as the exploitation of economies of scope in co-delivery of similar products.[2] Some models of intermediation, such as Diamond (1984) and Ramakrishnan and Thakor (1984) have argued that bank diversification increases bank market credibility in their role of overcoming information asymmetry by screening loan applicants and monitoring approved loans. Alternatively, evidence has been presented that bank focus upon a specified product line fully exploits the bank's managerial expertise and reduces potential agency conflicts (Jensen, 1986; Berger and Ofek, 1996).

Empirical studies such as DeYoung and Rice (2004), Stiroh (2006) and Stiroh and Rumble (2006) have employed non-interest income as a percent of total income to measure bank portfolio diversification. DeYoung and Rice (2004) found that higher levels of non-interest income is associated with worsening risk-return trade-offs, a conclusion confirmed by Stiroh (2006) and Stiroh and Rumble (2006). It was found that the volatility of non-interest income is actually higher than that of interest margin income and that this volatility effect more than outweighed any portfolio diversification benefits.[3] Stiroh and Rumble (2006, p. 2158) suggested that bank management "… *may have gotten the diversification idea wrong* …." It was proposed that bank management may be pursuing absolute levels of returns and that the negative agency effects of 'too-big-to-fail' were encouraging a focus upon absolute levels of returns rather than considering risk and return simultaneously.[4]

The recent body of evidence in the United States (Schmid & Walter, 2009) and globally (Laeven & Levine, 2007) support the argument that agency costs dominate any benefits from income diversification or economies of scope. Nguyen (2012) concluded that increased non-interest income is associated with worsening risk-adjusted profits, and suggested that non-traditional activities have no obvious diversification benefits. Further, Elyasiani and Wang (2008) document that increased levels of non-interest income is associated with higher levels of information asymmetry. DeYoung and Rice (2004) found that well managed banks are less reliant upon non-interest income as a source of revenue, which also supports the view that there are negative agency effects of reduced interest income. Berger, et al. (2010) confirmed this evidence from the perspective of a large developing nation, China.

A European study by Lepitit et al. (2008) found that banks may be willing to use lower interest income from loans as a loss leading product in order to establish a long-run relationship with borrowing firms, with the intent of extracting the lost revenue via increased fee income. A negative relationship between non-interest income and loan prices was documented by Lepitit et al. (2008) and it was concluded that higher non-interest income is associated with lower lending rates and under-pricing of borrower risk. Supportive of this result was the finding of Williams (2007) that bank net interest margins in Australia were negatively associated with bank loan loss experience, suggesting a perverse pricing for loan risk in Australia.

The global study by Laeven and Levine (2007) found strong evidence of a conglomerate diversification discount, which was attributed to the higher agency costs imposed by more complex corporate structures. In the case of the United States, Schmid and Walter (2009) concluded that functional diversification by financial institutions is value destroying.[5] The European study by van Lelyveld and Knot (2009) found no effect upon bank value from diversification. Differences in institutional arrangements between the United States, where commercial and investment banking has combined only relatively recently, and Europe, with its longer history of universal banking, are a possible reason for these differences (DeYoung & Rice, 2004).

There are exceptions to this body of evidence. DeYoung and Torna (2013) document that the probability of bank failure decreases as non-interest income increases. Engle et al. (2014) find that in nations with low levels of market concentration non-interest income is associated with increased systemic risk. However, for nations with above median levels of bank system concentration, no significant relationship between non-interest income and systemic risk was found.

[1] The 'too-big-to-fail' hypothesis suggests that here is a group of large banks in each financial system that are so central to ongoing economic prosperity that the government / regulator will support them in times of financial crisis. This results in an implicit government guarantee for these banks (See for example, Kaufman (2014)).

[2] Arguments in favor of bank loan portfolio diversification have been based upon Diamond (1984) under the assumption of no agency conflicts between bank and borrower. See also Saunders and Walter (1994) and DeYoung and Roland (2001) for a review of the relevant literature. Acharya, et al. (2006) find that agency conflicts generate diseconomies of scope in diversification in the case of Italian bank loan portfolios.

[3] DeYoung and Roland (2001) provide three reasons for the higher volatility of non-interest revenue (i) lower switching costs for fee for service revenue as compared to loan relationships, (ii) higher operating leverage, and (iii) higher financial leverage.

[4] A recent study by De Haan and Poghosyan (2012) has found that US non investment banks with higher levels of non-interest income have higher volatility of return on assets and return on equity.

[5] Interestingly Clarke, et al. (2007) document an increased focus upon retail banking by US banks prior to the GFC, attributed mainly to its superior risk-return characteristics.

3. Data and methodology

3.1. Data

This study employs the confidential quarterly regulatory data provided by all Australian banks to the Australian Prudential Regulation Authority (APRA) as a primary source. This data has the benefit of higher frequency than data sourced from annual reports as previously used for analysis. This data includes the second quarter of 2002 to the final quarter 2014. This data set will allow analysis of the period leading up to including and following the financial crisis of 2007 to 2008. Thus, this paper determines if the post-financial crisis period has seen any structural changes in the relationship between bank risk and revenue composition. Banks in Australia are conventionally characterized into four categories; (i) the major banks; (ii) the other Australian banks; (iii) foreign owned banks and (iv) foreign branches. There are six banks characterized as major banks by APRA, the Big Four (ANZ, Commonwealth Bank, National Australia Bank and Westpac) plus two smaller banks, (Bank West and St George), both of which have been acquired by one of the Big Four Banks since mid-2008. The major banks have a market share in December 2014 of approximately 80% of banking assets and so are the dominant banks in Australia.[6] The other Australian banks consist of a mix of regionally focused mainly retail banks, a converted merchant bank with a wholesale focus and a combined bank-insurance group. There are eight other Australian banks in this study. The foreign banks are fully licensed and separately incorporated banks which are fully owned by foreign banks or financial institutions.[7] Foreign banks in Australia are legally able to transact in all aspects of Australian banking but choose to mainly remain focused upon wholesale banking and off balance sheet activity. There are twelve foreign banks in this study. Foreign branches are not separately incorporated in Australia and operate subject to the restriction that they are to confine themselves to wholesale banking and off balance sheet activity and are not permitted to raise funds from retail depositors. These banks are not separately incorporated and so they are not required to hold capital in Australia. Thus, data for key control variables traditionally used in banking studies, such as capital holdings, is not available and foreign branches are not included in this study.[8]

3.2. Dependent variables

This study employs two separate measures of bank revenue risk as dependent variables, all calculated on the basis of annual rolling averages of the quarterly data.[9] As discussed by Parkinson (1980) as well as Alizadeh, et al. (2002), standard deviation or variance, as traditionally applied to measure risk suffers from some empirical difficulties, especially when calculated using relatively few observations, as in this study. Thus, following Alizadeh et al. (2002) this study uses a range-based measure of revenue volatility; log (high-low) of four quarters, as a less noisy approximation of the underlying volatility as compared to the alternatives. Range-based volatility measures are calculated for both return on assets (before tax) as well as profit before tax.[10]

Following, Acharya et al. (2012) and Brunnermeier et al. (2012) market-based estimates of bank risk is used for those banks listed on the Australian Stock Exchange (ASX) during the study period. The ex-ante marginal expected shortfall (MES) is calculated on a rolling annual basis for each quarter for each listed bank in that quarter. As all Foreign subsidiary banks and Foreign banks operating in Australia are not listed, this results in a reduction of the number of banks in this sub-sample. Following Acharya et al. (2012), MES will be estimated as the average return of each bank in the worst five per cent (or one per cent) of the trading days in the market for that year.[11] As discussed by Acharya, et al. (2010), MES has several advantages over other measures such as Value at Risk, including ease of computation; MES also allows for extreme events rather than discarding events that lie beyond a designated cut-off point; MES does not impose a distributional shape upon the data, such as a normal distribution; and MES is able to predict the worst performing banks during the 2007–2009 financial crisis.

In addition, the historical Value at Risk (VaR) (based on share market returns) at the five or one per cent level will be calculated for each listed bank. Historical VaR is used as it does not require any assumptions with respect to distributional properties of returns.[12] Bank share prices and returns from the Australian All Ordinaries Index are obtained from DataStream and all returns are adjusted for dividends and capitalization changes.

Finally, a subset of all banks in Australia are authorized by APRA to use an internal model to calculate their Value at Risk due to exposure to market risk (henceforth Internal VaR [IVaR]). The bank-specific IVaR for each of these banks includes the end of quarter IVaR, the average of the last 60 trading days market IVaR as well as a scaled IVaR figure. The scaled IVaR reflects the requirements under Australian Prudential Standard 116 (APS 116) that IVaR figures are subject to back-testing. The scaling factor reflects the frequency with which the IVaR figure does not match the trading book outcomes and results in additional multiplicative factor being added to the capital requirements resulting from the IVaR calculations.[13] In each case the reported IVaR figures are divided by total equity when used as dependent variables.

The descriptive statistics for the dependent variables are shown in Table 1. Panel A of Table 1 shows the two measures of revenue risk used in this study as well as return on assets before tax. This is the largest sample used in the study. Panel B shows the marginal expected shortfall (MES) at the five and one per cent levels as discussed by Acharya et al. (2012) and Brunnermeier et al. (2012), as well as the historical stock market Value at Risk (Jorion, 2000) at the one and five percent levels. As not all banks licensed in Australia are listed on the Australian stock exchange,

[6] See APRA Quarterly Authorised Deposit-taking Institution Performance Statistics, June 2015, available at http://www.apra.gov.au/adi/Publications/Pages/adi-quarterly-performance-statistics.aspx

[7] All of the foreign banks operating in Australian over the study period are 100% foreign owned.

[8] Removing the Foreign Branches from this study results in a considerable reduction in degrees of freedom as Foreign Branches make up the largest number of banks in Australia, but with a small market share. However, it is argued that as wholly owned branches not legally separate from the parent and not permitted to raise retail deposits in Australia, these banks are subject to different incentives and regulations as compared to the domestically incorporated banks. Additional study of foreign branches would provide a worthwhile extension to this study.

[9] De Haan and Poghosyan (2012) also employ a rolling average technique, with standard deviations over 4 and 8 quarters employing fixed effects estimation. This paper employs a more sophisticated estimator of both revenue volatilities as well as an estimation method that employs an alternative control for time series properties.

[10] Assistance of the statistics department of APRA in ensuring that different reporting methods across banks with respect to insurance activity had no impact on measured profits is gratefully acknowledged.

[11] The All Ordinaries Index will be used to represent the Australian market index. It encompasses the largest 500 companies in Australia by market capitalization. All returns calculated are adjusted for dividends.

[12] As shown in Allen and Powell (2012) the correlation between parametric, historical and Monte Carlo VaR for Australian listed banks is in in excess of 97%.

[13] See for further detail McAleer (2009) as well as APS 116, available at http://www.apra.gov.au/adi/PrudentialFramework/Documents/Basel-III-Prudential-Standard-APS-116-(January-2013).pdf

Table 1
Dependent Variables. (All Banks 2nd Quarter 2002 to 4th Quarter 2014).

Panel A bank specific measures			
26 Banks	Obs	Mean	Std. dev.
Range-based volatility of ROA	1056	−0.341	0.709
Range-based volatility of Profits	1056	12.667	7.258
Capital adequacy ratio (%)	1004	15.394	11.883
Equity to assets ratio (%)	1056	9.357	6.753
Return on assets before tax (%)	1056	0.666	0.967
Panel B bank risk measures drawn from the share market.			
11 banks	Obs	Mean	Std. dev.
MES (5%)	439	−2.155	1.184
MES (1%)	439	−2.781	1.955
VaR (5%)	439	−2.421	1.272
VaR (1%)	439	−4.011	2.067
Panel C: all ordinaries historical value at risk			
Variable	Obs	Mean	Std. dev.
Historical Market VaR 5%	54	−1.534	0.703
Historical Market VaR 1%	54	−2.620	1.278
Panel D Bank internal measures of Value at Risk due to exposure to market risk.			
Variable	Obs	Mean	Std. dev.
7 banks			
Internal VaR end of quarter, scaled by equity %	318	0.059	0.119
Internal VaR 60 day average scaled by equity %	318	0.063	0.116
Internal VaR scaled by APRA (penalty factor between 3 and 5) for back testing breaches, scaled by equity %	318	0.195	0.360

Range-based volatility of ROA and Profits are calculated following Alizadeh et al. (2002) as log (high value – low value). MES is marginal expected short fall, following Acharya et al. (2010), Acharya et al. (2012) and Brunnermeier et al. (2012), VaR is the historical Value at Risk (Jorion (2000). Both are estimated using the previous one trading year on a rolling average basis.

this is a smaller sample than shown in Panel A. In Panel C the historical Value at Risk is shown for the Australian market index (the All Ordinaries Index) at both the one and five per cent levels to provide a benchmark for the data in Panel B.

Panel D of Table 1 shows the internally generated Value at Risk (IVaR) figures for a slightly different and smaller sample of banks who have approval from APRA under APS 116 to calculate their own estimate of their portfolio of exposures to market risk. All figures in Panel D are expressed as a per cent of bank equity. It is notable that these exposures to market risk are a relatively small proportion of bank equity on average.

3.3. Independent variables

In order to determine the impact of bank revenue diversification upon bank risk two alternative measures of revenue composition are employed. The first is non-interest income as a proportion of total bank revenue. As discussed above, a number of studies have used this measure to reflect bank revenue portfolio diversification, particularly DeYoung and Rice (2004), Stiroh (2006) and Stiroh and Rumble (2006). The second measure of bank revenue portfolio composition is a Herfindahl–Hirschman index based measure of revenue concentration as employed by Esho, et al. (2005). Revenue concentration is defined as the sum of the square of the revenue shares, and to implement this measure the revenue portfolio must be divided into a series of categories. Bank revenue is broken into six categories of revenues, each weight based upon the four quarter average on a rolling basis. Revenue from banking activities is considered as two categories, (i) interest revenue from lending activities and (ii) non-interest income from banking activities, such as account keeping fees and loan fees. Income from trading activities and income from the investment portfolio are treated as a single category due to the synergies between these two types of activity.[14] Investment banking activity, including revenue from underwriting, securitization, brokerage, funds under management, syndication and advisory services are also treated as a single category. Two categories reflecting other revenue not elsewhere categorized are included; (i) other interest income and (iii) other non-interest income. All portfolio weight measures are calculated using rolling annual averages of quarterly data.

There is considerable heterogeneity in the size of the banks comprising the sample used in this study. Thus, two alternative control variables are used to ameliorate possible size effects. Both the log of revenue and the log of revenue squared (or the log of asset and log of assets squared) are included in all models to control for size effects and to determine if there is any evidence of scale effects in terms of risk reduction as found by Esho et al. (2005) for the much smaller Australian credit unions. The issue of the relationship between bank size and bank risk is an important one after the 2008 financial crisis, as the issue of 'too-big-to-fail' has again become a central question for regulatory policy.[15] Additionally, results indicating any relationship between bank size and bank risk are relevant for merger policy in the banking industry. Where relevant, dummy variables representing bank type are included to control for any residual effects due to bank type.[16]

3.4. Control variables

This model also controls for other bank characteristics that impact upon bank risk. Risk-seeking banks are likely to have lower

[14] This also removes any potential problems due to differences in categorisation across individual banks.

[15] See for example the recent Dodd-Frank Act in the United States.

[16] A number of sub sample analyses are conducted as robustness tests and the differences in sample composition determine which set of dummy variables is appropriate.

Table 2
Independent Variables.
2nd Quarter 2002 to 4th Quarter 2014.

Variable	Obs	Mean	Std. dev.
Revenue concentration	1062	5697.43	1554.51
Non-interest income % of revenue	1062	18.43	18.21
Equity to assets ratio (%)	1066	9.48	7.47
Capital adequacy ratio (%)	1141	15.91	13.18
Growth of net loans %	1145	2.06	17.27
Bad debt charge scaled by assets %	1193	0.13	0.23
Log total assets (annual average)	1151	17.1	7.078
Log total revenue (annual average)	1062	14.03	7.02
Loan to assets ratio (%)	1068	0.6991	0.1674
Liquid assets (% of Assets)	992	3.35	3.96

Revenue concentration is measured as the Herfindahl–Hirschman Index (HHI) of revenue concentration, with bank revenue broken into six categories (i) loan interest income (ii) banking fees, (iii) trading and investment income (iv) investment banking income, (v) other interest income and (vi) other non-interest income. See also Table 3.

Table 3
Revenue Weights.
2nd Quarter 2002 to 4th Quarter 2014.

Variable	Obs	Mean	Std. Dev.
26 Banks			
Weight loan interest income	1055	67.705	19.673
Weight banking fees (Transaction fees, account keeping fees and similar)	1055	5.261	3.798
Weight trading and investment income	1055	14.629	9.835
Weight investment banking income	1055	5.441	11.535
Weight other interest income	1055	0.820	2.547
Weight other non-interest income	1055	6.143	12.379

Revenue from banking activities is considered as two categories, (i) interest revenue from lending activities and (ii) non-interest income from banking activities, such as account keeping fees and loan fees. Income from trading activities and income from the investment portfolio are treated as a single category due to the synergies between these two types of activity and to remove any potential biases due to differences in categorization by individual banks. Investment banking activity, including revenue from underwriting, securitization, brokerage, funds under management, syndication and advisory services are also treated as a single category. Two categories reflecting other revenue not elsewhere categorized are included; (i) other interest income and (iii) other non-interest income. All portfolio weight measures are calculated using rolling annual averages of quarterly data.

levels of capital (Merton, 1977), have lower quality loan portfolios and so report higher levels of bad debts, have higher levels of loan growth (Kwan and Eisenbeis, 1997), have higher loan to asset ratios (Stiroh and Rumble, 2006) and hold fewer liquid assets. Accordingly, the model includes either the capital adequacy ratio or the equity to total assets ratio to measure capitalization. The total charge for bad and doubtful debts scaled by assets is used to measure loan quality. Both growth in net loans and growth in net loans squared are used to represent risk due to asset growth. Following Kwan and Eisenbeis (1997), low to medium levels of asset growth are necessary for ongoing profitability and asset formation, while high levels of loan growth represent increasingly risky activity. Banks which utilize a higher proportion of their total asset base as loans are holding fewer financial reserves and as such are engaging in riskier activity, which is measured by the loan to asset ratio (Stiroh and Rumble, 2006). Further, banks with lower holdings of liquid assets are more likely to be risk-seeking; liquid reserves are measured using cash and liquid assets, (as defined by APRA), divided by total assets.

In order to control for the covariance effect between non-interest income and revenue concentration the model also includes an interaction term: non-interest income as a per cent of revenue * revenue concentration. Summary statistics for the independent variables used in this study are shown in Table 2.

3.5. Model

This research proceeds in two phases. In the first phase the general measures of bank portfolio diversification (as discussed above) are used as independent variables to determine if bank revenue diversification in general impacts upon bank risk and in which direction. In the second phase, revenue composition weights substitute for the portfolio diversification measures, following DeYoung and Roland (2001) and Esho et al. (2005). In order to ensure that the second phase model estimated does not suffer from singularity, these models are estimated without the revenue weight for loan interest income.[17] This means that the results for the revenue weight regressions can be interpreted as the change in risk resulting from an increased exposure to that revenue weight, with interest revenue from lending as the risk benchmark. The descriptive statistics of the banks revenue weights are shown in Table 3.

The model that will be estimated is:

$$Risk = f\begin{pmatrix} constant,\ portfolio\ composition, \\ [non\ interest\ income\ as\ a\ percent\ of\ revenue * \\ \quad portfolio\ concentration], \\ \log of total\ revenue, \\ [log\ of\ total\ revenue]^2, bank\ type\ dummy\ variable, \\ \quad control\ variables, \\ capital\ holdings,\ bad\ debts,\ loan\ growth, \\ \quad [loan\ growth]^2, \\ loan\ to\ asset\ ratio,\ liquidity\ holdings \end{pmatrix} \quad (1)$$

Where: portfolio composition is alternatively (i) non-interest income as a percent of total revenue, (ii) revenue concentration, or (iii) revenue weights. In the case of the revenue weights model the interaction term will be omitted to reduce the impact of multicollinearity.

As can be seen from Table 3, interest income from lending activities remains the major source of bank income in Australia despite the observed increased involvement in less traditional fee based financial services.[18]

Examination of the correlations between the independent variables employed in the first phase of this research, shows that some combinations of variables are likely to induce multicollinearity, especially for the sub-sample analysis with lower degrees of freedom. The three measures of revenue composition are unsurprisingly highly correlated. Similarly the two size measures are highly correlated with each other, both loan growth squared and log of assets squared are highly correlated with, respectively, loan growth and log of assets. Additionally, the loan to asset ratio is highly correlated with the revenue composition measures and holdings of liquid assets are highly correlated with capital adequacy ratios. Bank equity holdings are highly correlated with size measures. Accordingly, the models are estimated with different combinations of the revenue composition measures to ensure the robustness of the results. As a result the models shown below do not include liquidity holdings and the loan to asset ratio has also been omitted. Further, capital adequacy is used to measure

[17] Models including the weight of loan interest income are also estimated and shown. As discussed below, the approach adopted reduces the potential for bias due to multicollinearity.

[18] See Williams and Rajaguru (2013) and Williams and Prather (2010) for a more detailed discussions of this issue in the Australian context.

capital holdings (instead of equity holdings) to further reduce any potential multicollinearity effects.

3.6. Method

The models employed in this study will be estimated using unbalanced panel regressions, as some of the banks in the study commenced operations after the first quarter 2002, or ceased Australian operations after 2002.[19] There is considerable heterogeneity across this sample in terms of both size and nature of activities. Furthermore, the independent variables are constructed as moving annual averages to match the calculation method required to calculate the risk measures used as dependent variables. Thus, it is appropriate to control for the time series properties implicit in this specification.

Two possible empirical formulations present themselves as best suited to the nature of the research design in this paper. The alternatives are a dynamic panel model or a Feasible GLS estimator. The dynamic panel generalized method of moments (GMM) estimator model commonly employed when using unbalanced panel regressions are the Arellano and Bond (1991) and Arellano and Bover (1995)/Blundell and Bond (1998) GMM models (henceforth ABB model). As discussed by Roodman (2009) this family of models are optimized for small T large N panels. In this case the data has a relatively small number of panels and the number of instrumental variables required would exceed the recommended rule of thumb that instruments should not be greater in number than the number of panels, even with a parsimonious specification.

The alternative is Feasible Generalized Least Squares Regressions which controls for both heteroscedasticity as well as bank-specific autocorrelation. Following Wooldridge (2010), a Wald test for serial correlation is conducted (as shown in Table 4 and following tables) to support the use of the FGLS correction for bank specific-autocorrelation. The Arellano and Bond (1991) test for autocorrelation is also conducted and shown.[20] The results support the presence of panel autocorrelation and thus the FGLS estimator is applied. The FGLS model suffers from fewer restrictive assumptions than the ABB model for this study in that the FGLS estimator allows for heterogeneity between banks in terms of autoregressive characteristics due to the differences in strategic focus, as well as differences in variance across the panels. Wald tests are also be used to test for the collective significance of the estimated coefficients in each model.[21] Further details are available in Baltagi (2008) and Wooldridge (2010).

4. Results

4.1. Revenue volatility

This first set of results considers the relationship between bank revenue composition and revenue volatility, as shown in Table 4. If the portfolio diversification argument is applicable to bank revenue we would expect that banks with higher levels of revenue concentration are riskier, and as banks diversify into non-interest revenue their revenue risk declines. Instead, it is found that higher levels of non-interest income are associated with increased revenue volatility, while increased revenue concentration is associated with lower risk. It should be noted that revenue concentration has a high correlation with lending income as a per cent of revenue. Thus, those banks with higher revenue concentration are most likely to be those most active in traditional lending activities. The interaction term (revenue concentration * non-interest income as a per cent of revenue) confirms that the covariance between these two income sources is dominated by increased risk arising from increased non-interest income. Sub-sample analysis considers the pre- and post-financial crisis periods separately, as well separate analysis of the three bank types in this study reveal some valuable insights into the changing nature of this relationship. It is particularly notable that the risk reducing impact of revenue specialization is notable before the financial crisis but not afterwards. In contrast, across the all bank sample, non-interest income is risk increasing both before and after the financial crisis. In the period before the financial crisis non-interest income is risk increasing both via the main effect and via the covariance effect. In the post-crisis period non-interest income is risk increasing only via the covariance effect. Overall, therefore, the portfolio diversification argument favoring increased non-interest income is not supported.[22]

The results of the regressions considering the relationship between revenue composition and bank risk for each of the three bank-type sub-samples are shown in Table 5. As shown in Table 4, the dummy variables representing major banks are consistently positive and significant. The dummy variable representing the other domestic banks is consistently negative for the post-financial crisis period. Thus, detailed analysis by bank type is appropriate. As the dominant banks in Australia, the major banks are the most important source of systemic risk from a regulatory perspective. Analysis of this sub-sample is somewhat constrained by a smaller sample size. The results for the major banks for the entire sample period and pre-financial crisis period are the same as those from the all bank sample. However, the post-crisis major bank sub-sample shows a change in this relationship, in that revenue composition no longer impacts on bank risk.

In terms of overall market share the other domestic banks are the next most important, but are quite diverse in nature, including traditional retail focused banks, fully licensed banks with a focus upon merchant and investment banking and a banking / insurance conglomerate. In the case of the Other Domestic banks the sub-period analysis again shows that the relationship between specialization, non-interest income and bank risk has shown a structural change after the financial crisis. Across the entire sample period it is found that specialization has no impact on the risk of the Other Domestic banks, while non-interest income is risk-increasing. In the period leading up to and including the financial crisis neither non-interest income nor revenue specialization has any impact on bank risk. In the post-financial crisis period revenue specialization is found to be risk reducing. This result is supportive of that of Williams and Prather (2010) who also found that non-interest income for the other domestic banks in Australia is not risk increasing.

The foreign banks as a group are considered to be specialists in the provision of investment banking style services.[23] Thus, it would be expected *a priori* that this type of financier would be most able to generate positive outcomes from their exposure to non-interest income. However, consistent with the previous all banks sample, non-interest income and the covariance between

[19] This applies mainly to the foreign banks and some of the smaller domestic banks. Exits were mainly due to restructuring Australian operations from foreign bank to foreign branch or reflected restructures at the home nation level. Some of the smaller Australian banks either merged with each other or were acquired by the major Australian banks, as mentioned above.

[20] See also Roodman (2009).

[21] The Wald Chi-squared has as its critical value a chi squared distribution with same number of degrees of freedom as the number of regressors in the model (excluding the constant).

[22] In the interests of conserving space, the regression results for range-based volatility of profits are omitted from Table 4 and the following tables. These results are available from the author on request.

[23] See for example Williams (1998), Sturm and Williams (2008), and Williams (2007).

Table 4
Revenue volatility regressions: all banks.

Panel A: All Periods: 2nd Quarter 2002 to 4th Quarter 2014.				
	(1)	(2)	(3)	(4)
Variables	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Revenue concentration		−8.52e−05***		
Non-interest Income % of revenue			0.00719***	
Covariance (revenue concentration, non-interest income)				2.32e−06***
Capital adequacy ratio (%)	0.0171***	0.0149***	0.0156***	0.0181***
Bad debt charge scaled by assets %	0.100	0.177**	0.0983	0.169**
Growth of net loans %	−0.000207	−0.000735	−0.000568	5.36e−05
Growth of net loans % squared	6.96e−06	2.29e−05*	1.04e−05	5.87e−06
Log Total Assets (annual average)	0.0504**	0.0297	0.0274	0.0178
Log total assets (annual average) squared	−0.00110*	−0.00100	−0.000593	−7.03e−05
Major bank	0.485***	0.388***	0.401***	0.301***
Other domestic bank	0.103	−0.00609	−0.0157	−0.0831
Post-2008	−0.108	−0.358*	−0.120	−0.0450
2007 to 2008	0.0447	−0.0130	0.0918*	0.0215
Constant	−1.290***	−0.196	−1.107***	−1.158***
Observations	1091	1005	1083	1005
Number of banks	37	36	37	36
Wald χ^2	191.9	309.1	217.2	363.4
Wooldridge test for AR1	14.639***	8.439***	15.185***	8.160***
Arellano-Bond test for AR1	20.11***	20.66***	18.56***	19.86***
Panel B: 2nd Quarter 2002 to 4th Quarter 2008.				
Revenue concentration		−0.000124***		
Non-interest income % of revenue			0.0120***	
Covariance (revenue concentration, non-interest income)				3.39e-06***
Capital adequacy ratio (%)	0.0172***	0.0147***	0.0142***	0.0188***
Bad debt charge scaled by assets %	−0.0327	0.246*	−0.0931	0.249*
Growth of net loans %	−0.00306*	−0.00147	−0.00362**	−0.000864
Growth of net loans % squared	2.78e−05*	3.11e−05*	3.21e−05**	9.07e−06
Log total assets (annual average)	−1.952***	−0.694	−1.319***	0.163
Log total assets (annual average) squared	0.0433***	0.0138	0.0294***	−0.00337
Major bank	0.230	0.613***	0.243*	0.442***
Other domestic bank	0.630***	0.480***	0.338***	0.102
2007 to 2008	−0.0519	−0.0133	0.0330	0.0462
Constant	20.96***	8.571*	13.67***	−2.984
Observations	556	504	556	504
Number of banks	27	26	27	26
Wald χ^2	170.4	188.1	251	246.5
Wooldridge test for AR1	3.228*	0.618	3.221*	0.787
Arellano-Bond test for AR1	14.78***	14.41***	13.53***	13.60***
Panel C: 1st Quarter 2009 to 4th Quarter 2014.				
Revenue concentration		−3.44e−05		
Non-interest Income % of revenue			0.000411	
Covariance (Revenue concentration, non-interest income)				1.21e-06**
Capital adequacy ratio (%)	0.0288***	0.0223**	0.0289***	0.0218**
Bad debt charge scaled by assets %	0.181**	0.158*	0.182**	0.162*
Growth of net loans %	−0.00191	−0.00382	−0.00246	−0.00368
Growth of net loans % squared	−5.14e−05	−3.78e−05	−5.38e−05	−3.41e−05
Log total assets (annual average)	0.0813**	0.0399	0.0764**	0.0355
Log total assets (annual average) squared	−0.00141	−0.001000	−0.00135	−0.000893
Major bank	0.246**	0.336***	0.262**	0.299***
Other domestic bank	−0.202***	−0.167**	−0.209***	−0.206***
Constant	−1.636***	−0.964**	−1.604***	−1.187***
Observations	535	501	527	501
Number of banks	29	29	29	29
Wald χ^2	130.5	118.4	127	126.6

(*continued on next page*)

Table 4 (*continued*)

Panel C: 1st Quarter 2009 to 4th Quarter 2014.				
	(1)	(2)	(3)	(4)
VARIABLES	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Wooldridge test for AR1	11.917***	6.917	17.098***	5.689**
Arellano-Bond test for AR1	10.57***	11.82***	10.45***	11.50***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$ Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Range-based volatility of ROA is calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance (Revenue Concentration, Non-interest Income) = Revenue Concentration * Non-interest Income. Major Bank is a dummy variable representing the 4 to 6 major banks is Australia (as defined by APRA). Other Domestic banks is a dummy variable representing all non-major Australian banks. Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008.

non-interest income and revenue composition are both found to be risk increasing. There is no evidence that revenue specialization has any impact on revenue risk for foreign banks in either of the two sub-samples prior to, or after, the financial crisis. However, the all-period foreign banks sub-sample does indicate that specialization does generate risk reduction effects for foreign banks.

Bank capital adequacy ratios are positively correlated with bank revenue risk. Thus, those banks with higher risk revenue portfolios are partially compensating for this increased risk via increased capital holdings. This is perhaps due to regulatory intervention by APRA.[24] It is noteworthy that this positive relationship is mainly ascribable to the other domestic banks, particularly prior to the financial crisis and to the foreign banks (which generally hold higher levels of capital) for all periods and sub-periods.

Unsurprisingly, banks with higher levels of bad debts also display increased revenue volatility, but this result is sensitive to the time period and bank sub-sample. In the case of the major banks, bad debts are found to have a negative relationship with revenue volatility in the pre-financial crisis periods, but was not significant otherwise. The observed positive relationship between revenue volatility and bank bad debts is mainly driven by the other domestic banks across the entire sample period (but not in either of the two time period sub-samples), and the foreign banks, especially after the financial crisis.

The all bank sample found some evidence that higher levels of bank loan growth, as measured by loan growth squared, is associated with lower bank revenue risk, but analysis of the two sub-periods did not find any confirmatory evidence. The major bank sub-sample found loan growth to be risk increasing at a decreasing rate (opposite to Kwan and Eisenbeis, 1997), for the entire sample period. Again, the two sub-periods samples found limited evidence to suggest loan growth has a relationship with bank revenue risk. The other domestic banks all-periods sub-sample found a U-shaped relationship between loan growth and bank revenue risk, supporting Kwan and Eisenbeis (1997) in that lower levels of loan growth are risk reducing while higher levels of loan growth, as measured by loan growth squared, are risk increasing. For the sub-period up to the end of 2008 loan growth was found to be risk reducing for the other domestic banks, but no effect was found for higher levels of loan growth as measured by loan growth squared. The post-2008 sub-period found no relationship between loan growth and bank revenue risk. In the case of the foreign banks limited evidence was found that loan growth impacts upon revenue risk, perhaps due to the foreign banks having a higher focus upon the delivery of non-lending financial products.

[24] This argument is supported by the ancillary finding (not shown) that banks with higher revenue volatility also tend to hold higher levels of liquid assets.

The issue of too-big-to-fail is an important policy issue after financial crisis of 2007–2008 (Kaufman, 2014) and therefore the relationship between bank size and bank risk has important policy implications. The results in Table 4 Panel A illustrates that increased bank size is associated with increased bank risk at a decreasing rate, and compared to the foreign banks as the reference set, the major banks display higher levels of revenue volatility. These results are consistent with the morally hazardous incentives created by the implied guarantee caused by too-big-to-fail incentives (Saunders, et al., 1990). The results for the two sub-periods of before and after 2008 confirm this result. In addition, the results for the post-crisis sub-sample also show the other domestic banks having lower risk than the foreign banks, while the major banks remain riskier.

In the case of the major banks, the result of size being associated with increased bank risk at a decreasing rate is confirmed for the sample covering the entire time period as well as for the two sub-samples of before and after 2008. In contrast, the results for the sub-sample of the other domestic banks across the entire sample period finds that increases in size is associated with lower bank risk, until a critical point is reached, where upon diseconomies of scale in risk reduction occur and the risk seeking incentives resulting from too-big-to-fail status dominate. The sub-sample for other domestic banks in the period before 2008 confirm the above result. However, the post-2008 results find that risk reductions due to increased size for other domestic banks is weaker. Given that the major banks are observed to have a positive relationship between revenue risk and size, it will be argued in this paper, consistent with the Australian bank efficiency study of Sturm and Williams (2004), that the major banks are operating at a size that does not generate any benefit in terms of risk reduction, but the other domestic banks still have the potential to benefit from scale economies in terms of revenue risk reduction.

In the case of the foreign banks it is found that increases in size is associated with increased risk across the entire sample period and for the post-2008 sub-sample. Given that the foreign banks in Australia, both individually and collectively, lack sufficient size to be classified as too-big-to-fail, this increased risk associated with size is due to some other factor most likely associated with their status as multinational banks. Further research of this facet of multinational banking would be a worthwhile extension of this study.

This study also included a dummy variable to represent the post-financial crisis period (after 2008) as well as a dummy variable for the financial crisis period of 2007 to 2008. Overall, bank risk declined after 2008, due to lower risk of the other domestic banks. In contrast the risk of the major banks, as measured by revenue volatility, increased after 2008, which confirms the hypothesis of increased risk due to too-big-to-fail effects. Little evidence

Table 5
Revenue volatility regressions: by bank category.

Panel A: major banks

VARIABLES	All Periods: 2nd Quarter 2002 to 4th Quarter 2014			2nd Quarter 2002 to 4th Quarter 2008			1st Quarter 2009 to 4th Quarter 2014		
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Revenue concentration	−6.57e−05**			−0.000102***			−2.12e−05		
Non-interest Income % of revenue		0.00274			0.00374			0.00559	
Covariance (revenue concentration, non-interest income)			1.39e−06***			2.37e−06***			1.11e-06*
Capital adequacy ratio (%)	−0.00626	−0.0124	−0.0158	0.0351	0.0483	0.0226	−0.0681	-0.0767*	-0.0709*
Bad debt charge scaled by assets %	0.0481	−0.151	0.0522	−4.32e−05	−0.633**	0.00200	0.0746	0.0372	0.0887
Growth of net loans %	0.0180***	0.0151**	0.0190***	0.0140	0.00667	0.0207**	0.0227	0.0209	0.0204
Growth of net loans % squared	−0.000292*	−0.000385**	−0.000292**	−0.000246	−8.41e−05	−0.000613	0.000216	0.000208	0.000197
Log total assets (annual average)	1.402**	1.102*	1.402***	10.02***	12.64***	11.43***	1.820**	1.383	1.646**
Log total assets (annual average) squared	−0.0260**	−0.0172	−0.0258**	−0.195***	−0.244***	−0.221***	−0.0456**	-0.0348	-0.0413**
Post-2008	4.650***	5.332***	4.746***						
2007 to 2008	−0.128**	−0.113*	−0.0965	−0.0551	0.0319	0.0392			
Constant	−18.54**	−17.09**	−19.06***	−128.5***	−164.5***	−148.2***	−15.51**	-11.71	-14.14**
Observations	246	258	246	150	162	150	100	100	100
Number of banks	6	6	6	6	6	6	4	4	4
Wald χ^2	36.74***	38.12***	49.41***	54.27***	36.12***	68.11***	15.90***	18.39***	20.87***
Wooldridge test for AR1	82.293***	75.786***	123.770***	30.639***	28.469***	42.285***	108.358***	48.085***	124.246***
Arellano-Bond test for AR1	7.33***	7.64***	7.35***	3.57***	4.52***	4.03***	4.62***	5.02***	2.53**

Panel B; other domestic banks

Variables	All periods: 2nd Quarter 2002 to 4th Quarter 2014.			2nd Quarter 2002 to 4th Quarter 2008.			1st Quarter 2009 to 4th Quarter 2014.		
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Revenue concentration	−4.75e−05*			2.56e−05			-6.76e-05**		
Non-interest income % of revenue		0.00985***			0.00241			0.00240	
Covariance (revenue concentration, non-interest income)			2.49e−06***			−8.83e−08			6.40e-07
Capital adequacy ratio (%)	0.0223**	0.0229*	0.0262***	0.0289**	0.00875	0.0188	−0.00306	0.00427	0.00173
Bad debt charge scaled by assets %	0.487***	0.212	0.399**	0.142	−0.181	0.173	0.265	0.108	0.140
Growth of net loans %	−0.00476**	−0.00530**	−0.00467**	−0.00430**	−0.00715**	−0.00480**	−0.00609	−0.00383	−0.00470
Growth of net loans % squared	4.71e−05***	4.55e−05***	2.84e−05**	−1.58e−06	1.33e−05	3.19e−06	−5.12e−05	−8.42e−05	−8.96e−05
Log total assets (annual average)	−0.130**	−0.0672	−0.176***	−8.728***	−9.101***	−8.950***	−0.264***	−0.177	−0.263**
Log total assets (annual average) squared	0.00263	0.000562	0.00444**	0.191***	0.199***	0.195***	0.00810	0.00689	0.00931*
Post-2008	−1.189***	−1.106***	−0.829***						
2007 to 2008	0.253**	0.300**	0.299***	0.0805	0.0952	0.0648			
Constant	1.434*	0.441	0.814	99.01***	103.4***	101.9***	1.470***	0.173	0.851*

(*continued on next page*)

Table 5 (*continued*)

Observations	365	401	365	155	169	155	210	232	210
Number of banks	19	19	19	8	8	8	17	17	17
Wald χ^2	109.9***	101.9***	126.2***	199.6***	140.2***	168.3***	34.57***	8.019	26.22***
Wooldridge test for AR1	2.396	4.617***	2.081	0.001	0.214	0.004	6.252**	8.438**	1.376
Arellano-Bond test for AR1	9.60***	7.18***	8.51***	0.53	0.91	0.64	6.22***	4.89***	6.33***

Panel C: foreign banks all periods: 2nd Quarter 2002 to 4th Quarter 2014.

	All Periods: 2nd Quarter 2002 to 4th Quarter 2014.			2nd Quarter 2002 to 4th Quarter 2008.			1st Quarter 2009 to 4th Quarter 2014.		
Variables	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Revenue concentration	−9.38e−05**			−8.10e−05			−4.83e−06		
Non-interest income % of revenue		0.0100***			0.0152***			5.54e−-05	
Covariance (revenue concentration, non-interest income)			5.31e−06***			7.70e−06***			2.71e−06***
Capital adequacy ratio (%)	0.0165***	0.0160***	0.0186***	0.0138***	0.0111***	0.0133***	0.0421***	0.0420***	0.0325***
Bad debt charge scaled by assets %	0.203**	0.248**	0.149	0.203	0.150	0.201	0.249***	0.291***	0.191*
Growth of net loans %	0.000200	−0.000920	0.000750	−0.000241	−0.00479*	−0.000334	−0.00481	−0.00466	−0.00649
Growth of net loans % squared	−1.77e−05	−2.20e−05	−2.23e−05	7.76e−05*	6.40e−05	9.10e−05*	−0.000288***	−0.000274***	−0.000225***
Log total assets (annual average)	0.145**	0.166**	0.154**	2.436	−0.973	0.320	0.228***	0.227***	0.180***
Log total assets (annual average) squared	−0.00341	−0.00435**	−0.00350*	−0.0555	0.0220	−0.00669	−0.00116	−0.00143	−0.00167
Post-2008	0.343	0.403	0.470						
2007 to 2008	−0.00450	0.152	−0.0385	−0.0163	0.0504	−0.0879			
Constant	−1.632**	−2.512***	−2.709***	−26.84	9.704	−4.919	−3.031***	−3.056***	−2.619***
Observations	394	424	394	199	225	199	195	199	195
Number of banks	12	13	12	12	13	12	9	9	9
Wald χ^2	94.26***	71.18***	124.4***	90.41***	74.13***	112.7***	267.8***	277.9***	286.3***
Wooldridge test for AR1	22.732***	36.717***	22.817***	26.289***	45.475***	23.940***	19.317***	23.027***	19.532***
Arellano-Bond Test for AR1	13.48***	13.19***	13.14***	10.17***	9.99***	9.67***	6.61***	6.52***	6.68***

Major Banks are the 4 to 6 major banks is Australia (as defined by APRA). Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008. Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Range-based volatility of ROA is calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance Income Composition = Revenue Concentration * Non-interest Income. Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008. In the interests of parsimony only the results for range volatility of return on assets after tax are shown.
The Other Domestic banks are all non-major Australian banks.
The foreign banks are fully licensed and separately incorporated banks which are fully owned by foreign banks or financial institutions. All of the foreign banks operating in Australian over the study period are 100% foreign owned.

Table 6
Market risk models.

	All periods: 2nd Quarter 2002 to 4th Quarter 2014.		2nd quarter 2002 to 4th Quarter 2008.		1st quarter 2009 to 4th Quarter 2014.	
Variables	MES5	MES5	MES5	MES5	MES5	MES5
Revenue concentration	−0.000193***		−0.000410***		−7.82e−05	
Non-interest income % of revenue		0.00120		0.00777**		
Covariance (revenue concentration, non-interest income)						−0.0170***
Capital adequacy ratio (%)	−0.0284	−0.00655	0.0267	0.00521	0.0104	0.0263
Bad Debt Charge scaled by assets %	−0.468***	−0.492***	−0.610	−0.815*	−0.410**	−0.559***
Growth of net loans %	−0.0213***	−0.0118***	0.0111	0.0116*	−0.00782	−0.00440
Growth of net loans % squared	0.000205***	0.000101**	−0.000127*	−0.000165**	−0.000137	−0.000956**
Log total assets (annual average)	−0.0469	0.140	−0.968	2.351	0.110	0.879**
Log total assets (annual average) squared	−0.00789***	−0.00867***	0.000742	−0.0587	−0.00286	−0.00632
Major bank	0.745***	0.542***	2.177***	1.222***	−0.00692	−1.720**
Post-2008	−5.188***	−3.236***				
2007 to 2008	−0.219**	−0.131	−0.211**	−0.187*		
Constant	5.681***	0.238	22.95	−24.42	−3.092	−11.34***
Observations	425	447	241	263	184	184
Number of banks	11	11	11	11	8	8
Wald χ^2	183.5***	140.8***	164.6***	64.60***	16.27***	27.96***
Wooldridge test for AR1	57.219***	91.110***	15.499***	31.42***	42.358***	68.910***
Arellano-Bond test for AR1	13.83***	13.75***	10.30***	9.62***	8.77***	

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Covariance Income Composition = Revenue Concentration * Non-interest Income. MES (5%) is the marginal expects shortfall at the five per cent level. Marginal Expected Shortfall (MES) is calculated following Acharya et al. (2012). MES5 is the marginal expected shortfalls at the five per cent level. MES has been multiplied by -1 to allow consistent interpretation of estimated coefficients. Major Bank is a dummy variable representing the 4 to 6 major banks is Australia (as defined by APRA). Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008.

was found that the crisis period of 2007 to 2008 showed any difference to the other years in terms of revenue volatility. In the case of the foreign banks any time effects were absent.

4.2. Market-based estimates of bank risk

Following Acharya et al. (2012), several market-based estimates of bank risk in Australia have been used as dependent variables in the model developed previously. The ex-ante marginal expected shortfall (MES) at both the one and five prevent levels as well as the historical Value at Risk (VaR) at the one and five per cent levels have been used as dependent variables for the same models as presented previously. In order to allow consistent interpretation of the results when compared to the previous and subsequent results the MES and VaR values were each multiplied by minus one. As discussed by Acharya et al. (2012) and Engle et al. (2014) the tail distribution of bank stock returns, especially MES provide a valuable predictor of bank capital shortfalls in times of financial crisis. Table 6 has the results of the model using market-based estimates of bank risk as dependent variables, for the entire sample period as well as for the two sub-periods of before and after 2008.[25]

The results for the share market's perceptions of Australian bank risk are largely in accord with the measures of bank total risk found previously. In particular, bank non-interest income is found to be risk increasing across the two sub-periods in this study. It also notable that the stock-market measures of bank systemic risk do not show any relationship with bank capital adequacy ratios. This may simply reflect the share market's favorable perception of Australian bank's holding of capital in excess of the required capital adequacy ratio of eight percent (see Table 2). Loan growth and bank size are assessed by the stock-market as more important determinants of bank systemic risk than capital adequacy ratios in the Australian context. For the entire sample period of 2002–2014, the arguments of Kwan and Eisenbeis (1997) in the context of loan growth are supported. It is found that low to medium levels of loan growth are associated with lower risk, while higher levels of loan growth are associated with increased systemic risk. For the two sub-periods of pre-2008 and post-2008 these results are not as conclusive, with higher levels of loan growth, as measured by loan growth squared, being associated with lower risk.[26] This result could be due to the smaller sample size of these two sub-samples, and is worthy of further investigation in other banking systems where a larger number of listed banks can be considered. Interestingly, and in contrast to the previous results, higher levels of bank bad debts (lower loan quality) is associated with lower systemic risk. This however, could represent the stock-markets view that those banks which are more active in lending (and thus have proportionately higher bad debts) are less risky due to their increased specialization. Again, further investigation in an environment with a larger number of listed banks has the potential bring clarity to this issue.

The size measures indicate the stock-market's view of the trade-off between the bailout effects of being too-big-to-fail versus the moral hazard effects of being too-big-to-fail. The largest banks, as measured by log of assets squared, are viewed as less risky due to the bail-out effect and the risk-reducing effects of increased surveillance by the prudential regulator. On the other hand, dummy variables representing the major banks indicate that the largest banks are considered to be riskier (the moral hazard effect of being too-big-to-fail inducing risk seeking), especially up to 2008. In contrast, the post-2008 results indicate that the post-financial crisis period has seen a reduction in the perception of major banks systemic risk. Instead, the moral hazard channel of large bank risk-seeking is now most notable via the size effect

[25] In the interests of conserving space only the results for the MES estimates at the five percent level are shown. The results from the other estimates of stock market risk are available from the author on request.

[26] It is possible that this result reflects a reallocation of the bank's lending portfolio after the financial crisis. However, limitations on the number of available observations restrict further exploration of this issue.

Table 7
Internal market risk measures.

	All Periods: 2nd Quarter 2002 to 4th Quarter 2014.			2nd Quarter 2002 to 4th Quarter 2008.			1st Quarter 2009 to 4th Quarter 2014.		
Variables	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av
Revenue concentration	−1.97e−06			−9.11E−13			−5.74e−06*		
Non-interest Income % of revenue		9.63e−05			−6.84e−10*			0.000199	
Covariance (revenue concentration, non-interest income)			1.11e−08			−0.0000000000002*			3.21e−09
Capital adequacy ratio (%)	−0.00144	−0.00139	−0.00140	−1.24e−09	−1.45e−09	−1.21e−09	−0.00286***	−0.00256**	−0.00203**
Bad debt charge scaled by assets %	−0.00703	−0.00838	−0.0112*	−4.47e−08*	−4.02e−08*	−4.28e−08*	−0.0183**	−0.0193**	−0.0231***
Growth of net loans %	0.000325	0.000185	0.000270	1.01e-09	1.08e-09	1.05e-09	0.000266	0.000370	0.000366
Growth of net loans % squared	−3.27e−05*	−2.03e−05	−2.26e−05	−4.56E−11	−4.57E−11	−4.62E−11	−0.000188***	−0.000195***	−0.000201***
Log total assets (annual average)	0.0469***	0.0390**	0.0433***	2.48e−06***	2.67e−06***	2.60e−06***	0.132***	0.139***	0.144***
Log total assets (annual average) squared	−0.000470*	−0.000534**	−0.000573**	−4.75e-08***	−5.11e−08***	−4.99e−08***	0.000366	0.000343	0.000311
Major bank	−0.0624	−0.0252	−0.0362	−3.61e−07***	−3.98e−07***	−3.81e−07***	−0.465***	−0.484***	−0.498***
Post-2008	0.486**	0.342**	0.384**						
2007 to 2008	−0.000632	0.00105	0.000599	−2.34e−08***	−2.66e−08***	−2.50e−08***			
Constant	−0.828**	−0.616**	−0.693**	−3.19e−05***	−3.43e−05***	−3.34e−05***	−1.196***	−1.308***	−1.361***
Observations	315	317	315	150	150	150	165	167	165
Number of banks	8	8	8	7	7	7	7	7	7
Wald χ^2	147.6***	168.9***	226.2***	53.33***	58.32***	56.93***	222.6***	225.8***	209.7***
Wooldridge test for AR1	27.819***	26.643***	27.880***	58.169***	49.109***	48.209***	157.466***	137.485***	149.043***
Arellano-Bond test for AR1	13.53***	13.83***	13.72***	7.47***	7.37***	7.44***	6.93***	6.90***	6.88***

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Covariance Income Composition = Revenue Concentration * Non-interest Income IVaR60 is the bank specific internal estimate of Value at Risk due to market risk, averaged over the previous 60 trading days, scaled by equity.

(log of total assets). The negative relationship between systemic risk and major bank status could be due to increased prudential surveillance of major banks after the financial crisis or the perception of an increased likelihood of a government bailout due to the introduction of a government guarantee of a bank deposits in Australia in November 2008.[27]

4.3. Internal bank estimates of market VaR (IVaR)

As discussed previously, a subset of the banks operating in Australia are authorized to generate an estimate of their portfolio exposure to market risk. These internally generated estimates have been scaled by each bank's equity base and used as a dependent variable in the model developed in this paper. The results from these estimates are shown in Table 7. As shown in Table 1 these internal estimates of VaR (IVaR) are a small proportion of each banks' total equity.[28]

There is no evidence that bank revenue composition has any impact upon the bank's internally measured exposure to market risk. It is found that larger banks have proportionally higher exposures to market risk, both before and after the financial crisis, as measured the log of total assets. In the first sub-period (ending 2008) this increase in risk is non-linear, in that it increases at a decreasing rate. However, the post-financial crisis period finds this risk increase is linear in size.[29] In contrast, the dummy variable representing major bank status indicates that these banks have proportionately lower market risk after the financial crisis due to either (i) increased capital holdings due to risk aversion, or (ii) increased prudential oversight due to their large bank status. A worthwhile extension of this study would be to consider the manner in which the moral hazard effects of too-big-to-fail status are ameliorated by increased prudential oversight after the 2007–2008 financial crisis.

Some specialization effects are found, in that banks which are more active in the lending function (as measured by proportionately higher levels of bad debts and higher loan growth) tend to have lower levels of internally measured market risk. Those banks with higher levels of capital as measured by the capital adequacy process tend to have lower levels of internally measured market risk. Since the 2007–2008 and the anticipated introduction of the Capital Adequacy Mark III process Australian banks have been increasing their capital holdings.[30] The outcome has been that capital adequacy ratios have been rising while at the same time internal value at risk divided by equity has declined due to increased equity holdings.

4.4. The impact of revenue weights upon bank risk

Given that the portfolio diversification hypothesis is generally not supported (especially for revenue volatility and systemic risk) and non-interest income is found to be riskier than traditional interest margin income, it is valuable to identify which components

[27] It is notable that the observed post-crisis reduction in bank risk does not appear to be related to capital adequacy effects. This suggests that this risk reduction is due to enhanced surveillance and / or governance rather than capital enhancements.

[28] In the interests of conserving space only the results of the estimations sing IVAR calculated as an average of the previous 60 days are shown. Results of the estimations using alternative IVAR measures are available from the author on request.

[29] This difference could simply reflect the smaller sample available for the sub-period analysis. Again, further studies in an environment where further observations are available would be a valuable extension of this study.

[30] See, for example, Australian Prudential Regulation Authority (2012).

of a bank's revenue portfolio choice increase or reduce bank risk. Using five of the six revenue weights used to calculate the revenue concentration index to represent bank portfolio composition, the models are re-estimated for each measure of bank risk, the entire sample and all the sub samples, with the results shown in Table 8. One revenue weight category, interest income from loans, is not included to remove problems associated with singularity, as interest income from loans has a high correlation with the other weight categories. Additional regressions are presented in Table 8 that include the weights for interest income from loans only, to verify its risk impact. In effect this category becomes the benchmark for assessing the risk of the revenue composition decisions.

It is found that interest income from lending is risk reducing for all bank categories except for foreign banks for entire sample period and the post-2008 sub-sample. In the case of the sub-sample ending in 2008, interest income from lending is risk reducing for the all banks sub-sample, but is not statistically significant for any of the bank type sub-samples.

The results for the share market based estimates of bank risk (Marginal Expected Shortfall [MES]) are shown in Table 9. These results confirm that loan income is less risky for the periods leading up to and including 2008. However, after the financial crisis of 2007–2008, the share market's perspective has shifted and banks with increased exposure to lending income are viewed as riskier. Trading and investment income continues to be risk-reducing both before and after the financial crisis. However, fees from general banking activities (account keeping fees, loan fees and similar non interest incomes) reduce systemic risk after the GFC, and general interest income also reduces systemic risk (both before and after the financial crisis).

The models of banks internal measure of market risk, unsurprisingly, find that those banks more active in trading and investment activity are generally riskier (both before and after the financial crisis). These results are shown in Table 10. Consistent with the previous results, those banks with higher interest income from lending have less exposure to market risk after the financial crisis. However, in this case, the result represents increased proportionate exposure to lending reducing proportionate exposure to market risk.

4.5. Robustness analysis

In order to determine if revenue specialization is more important than institutional type, the sample was divided into three sub-samples according to the level of revenue concentration. For each of these three sub-samples the impact of non-interest income upon bank risk was re-examined and the revenue weights models were re-estimated. Table 11 has the results for the revenue volatility model. This analysis is supportive of the argument that non-interest income is risk increasing regardless of the degree of bank specialization for the entire sample period and period leading up to and including the financial crisis period of 2007–2008. However, these results are less conclusive for the post-2008 sub-sample and indicates that non-interest income may be risk reducing for that half of the sample closest to the median level of revenue concentration after the financial crisis of 2008.[31]

The revenue weights model was then re-applied to the sub-samples stratified according to revenue concentration. These results are shown in Table 12. Prior to the financial crisis of 2007–2008, trading and investment income reduces revenue volatility for the most and least concentrated banks, but not for those banks closer to the median of revenue concentration. After the financial crisis this pattern changes and trading and investment incomes is risk reducing for the most concentrated and median banks in terms of revenue concentration, but is risk increasing for those banks with the least most concentrated revenue portfolios. This change may represent the increased importance of revenue specialization after the financial crisis. In a similar vein, fees from banking activities (deposit and loan account fees etc.), are risk increasing for those banks with the most and median levels of revenue concentration and risk reducing for least concentrated revenue portfolios in the period up to and including the financial crisis. After the financial crisis it is the banks with the most concentrated revenue portfolios that benefit from risk reduction via banking fees, while the banks with median levels of revenue portfolio concentration experience risk increases from banking fees.

Across the entire sample period, those banks with more concentrated revenue portfolios, increased revenue volatility is associated with lower capital adequacy ratios. For those banks with the median or less concentrated revenue portfolios, increased revenue volatility is associated with higher capital adequacy ratios. Interest income remains risk reducing in all cases. Increased loan growth is risk increasing for both the median banks (in terms of revenue concentration) and banks with the most concentrated revenue portfolios. However, loan growth has no impact on the risk of banks with the most diversified (least concentrated) revenue portfolios. This difference between the results in Tables 8 and 9 most likely reflects the impact of multicollinearity in these smaller sub-samples (especially for the revenue weights model). A larger study will be necessary to bring clarity to this issue. Trading and investment revenue is risk reducing for those banks with the most and least most concentrated revenue portfolios, but has no impact on the risk of the median bank.

5. Conclusions and policy implications

Overall, this paper finds that in the Australian context combining interest and non-interest revenue does not generate any portfolio diversification benefit. Instead, the international body of evidence that non-interest income is riskier than interest income is confirmed. These results support the arguments of Schmid and Walter (2009), Acharya, et al. (2006) and Laeven and Levine (2007) that increased complexity generates agency costs that outweigh any portfolio diversification benefits. Elyasiani and Wang (2008) also have argued that increased complexity as represented by higher levels of non-interest income is associated with increased information asymmetry, and it is possible and likely that this information asymmetry also contributes to higher bank risk. It is also found that Australian bank systemic risk (tail risk) is increased by non-interest income.

The role of bank revenue specialization both before and after the financial crisis of 2007–2008 has also been explored. It is found that specialization was risk reducing prior to the financial crisis. However, after the 2008 crisis revenue specialization increases major bank risk, reduces the risk of other domestic banks and has no discernible impact on the risk of the foreign banks (which are the most specialized banks as a sub-group). This result indicates that there is an optimal mix between size, risk and revenue diversification that is worthy of further investigation in both Australia and other banking systems, particularly where increased observations are available. Further, the financial crisis has changed the relationship between bank risk and revenue composition in Australia (at the margins) and further study of this change in other nations would be a valuable extension of this current paper. As the Australian banking system was relatively unaffected by the financial crisis of 2007–2008, this changed relationship may be due to institutional specific features relating to the prudential

[31] A more detailed discussion of this issue is below.

Table 8
Revenue weights regressions.

Panel A: all periods: 2nd Quarter 2002 to 4th Quarter 2014

.	All banks		Major banks		Other domestic banks		Foreign banks	
Variables	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Weight interest income from loans	−0.009***		−0.00319		−0.0107***		−0.00146	
Weight Banking Fees		0.022***		0.0307*		−0.0441***		0.0315***
Weight trading and investment income		−0.0125***		0.00766		−0.00347		−0.0168***
Weight investment banking income		0.0293***		0.0438***		0.0166***		0.0250
Weight other interest income		0.0168		1.190		−0.0237		0.0111
Weight other non-interest income		0.0103***		0.00339		0.00489		0.0282***
Capital adequacy ratio (%)	0.0131***	0.0169***	−0.0113	−0.00560	0.00824	−0.000426	0.0189***	0.0154***
Growth of net loans %	−0.00120	−0.000208	0.0191***	0.0157***	−0.00706***	−0.00618***	0.000903	0.000620
Growth of net loans % squared	2.33e−05*	3.42e−06	−0.000322**	−0.000251	5.33e−05***	3.91e−05***	−2.79e−05	−2.26e−08
Bad debt charge scaled by assets %	0.149*	0.158**	0.0413	−0.0311	0.373**	0.266*	0.212**	0.107
Log Total Assets (annual average)	0.0208	0.0216	1.523***	1.167*	−0.202***	−0.169***	0.120	0.155***
Log total assets (annual average) squared	−0.000890	−0.000235	−0.0282**	−0.0214	0.00394**	0.00356**	−0.00215	−0.00433***
Major bank	0.463***	0.279***						
Other domestic bank	−0.00945	−0.186***						
Post-2008	−0.413*	0.0200	5.051***	4.044**	−1.437***	−1.269***	0.513	0.151
2007 to 2008	−0.0127	0.0567	−0.128**	−0.0933	0.245**	0.191*	−0.0293	−0.0877
Constant	0.0719	−1.076***	−20.23***	−16.42*	2.914***	1.964***	−2.203**	−2.022***
Observations	1005	1005	246	246	365	365	394	394
Number of banks	36	36	6	6	19	19	12	12
Wald χ^2	318.9***	363.6***	32.41***	44.31***	119.9***	162***	82.38***	178.4***
Wooldridge test for AR1	8.262***	7.321***	64.645***	75.034***	1.735	2.442	21.62***	21.614***
Arellano-Bond test for AR1	20.45***	18.71***	7.93***	6.63***	8.12***	7.84***	13.45***	11.77***

Panel B: weights regressions by bank type 2nd Quarter 2002 to 4th Quarter 2008.

	All banks		Major banks		Other domestic banks		Foreign banks	
Variables	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Weight interest income from loans	−0.0136***		−0.00714*		0.00184		0.00191	
Weight banking fees		0.0198**		0.00281		0.000783		0.0650***
Weight trading and investment income		−0.00914**		0.00264		−0.00416		−0.0139**
Weight investment banking income		0.0223***		0.0252		−0.00768*		−0.0220
Weight other interest income		−0.00166		1.905		−0.0455		0.00182
Weight other non-interest income		0.0151***		0.0107**		0.00316		0.0273***
Capital adequacy ratio (%)	0.0140***	0.0175***	0.0299	0.00426	0.0269*	0.0550***	0.0180***	0.0123**
Growth of net loans %	−0.00201	−0.000834	0.0150	0.0155	−0.00441**	−0.00288**	0.00122	−0.00203
Growth of net loans % squared	2.93e−05*	1.85e−05	−0.000309	−0.000302	−1.59e−07	−1.05e−05	5.31e−05	0.000118**
Bad debt charge scaled by assets %	0.229	0.206	−0.0757	0.00846	0.164	0.241	0.193	0.244
Log total assets (annual average)	−0.182	−0.133	11.55***	13.44***	−9.164***	−9.922***	2.267	−0.0536
Log total assets (annual average) squared	0.00315	0.00328	−0.224***	−0.261***	0.200***	0.216***	−0.0513	0.000925
Major bank	0.671***	0.323						
Other domestic bank	0.300***	0.0101						
2007 to 2008	−0.0135	0.0415	−0.0527	−0.0681	0.0684	0.0492	−0.0550	−0.104
Constant	2.726	0.492	−148.3***	−173.0***	104.0***	112.7***	−25.90	−0.0759
Observations	504	504	150	150	155	155	199	199

(*continued on next page*)

Table 8 (*continued*)

Number of banks	26	26	6	6	8	8	12	12
Wald χ^2	205.5***	206.6***	35.98***	50.60***	186***	369.9***	83.37***	151.9***
Wooldridge test for AR1	0.812	0.587	21.548***	21.623***	0.036	2.279	22.553***	12.088***
Arellano-Bond test for AR1	14.29***	13.24***	4.20***	3.59***	0.6	0.79	10.14***	8.62***

Panel C: weights regressions by bank type 1st Quarter 2009 to 4th Quarter 2014.

Variables	All Banks		Major Banks		Other Domestic Banks		Foreign Banks	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Weight Interest income from loans	−0.000934		0.00863		−0.00655***		0.00141	
Weight banking fees		0.0342***		−0.0981**		0.000317		0.0343***
Weight trading and investment income		−0.0152***		−0.0255*		0.00804		−0.0218***
Weight investment banking income		0.0238***		0.0167		0.0154*		0.0248
Weight Other Interest Income		0.0237**		1.557		−0.0817*		0.0174*
Weight other non-interest Income		0.00498		−0.0115**		0.00214		0.00654
Capital adequacy ratio (%)	0.0248***	0.0196***	−0.0622	−0.0467	−0.0138	−0.0146	0.0422***	0.0168**
Growth of net loans %	−0.00327	−0.00409	0.0166	0.0243	−0.00755*	−0.00858**	−0.00475	−0.00718
Growth of net loans % squared	−3.20e−05	−8.49e−05*	−4.70e−06	0.000588	−7.76e−05	−0.000201	−0.000301***	−0.000117
Bad debt charge scaled by assets %	0.164*	0.145*	0.0238	−0.00790	0.230	0.333	0.250***	0.213**
Log total assets (annual average)	0.0454	0.0745**	1.692	0.807	−0.329***	−0.469***	0.232***	0.121*
Log total assets (annual average) squared	−0.00115	−0.000936	−0.0394	−0.0270	0.0102*	0.0170**	−0.000943	−0.00248
Major bank	0.355***	0.117						
Other domestic bank	−0.151**	−0.225***						
Constant	−1.189***	−1.451***	−15.73*	−4.865	2.117***	2.161***	−3.221***	−1.627***
Observations	501	501	96	96	210	210	195	195
Number of banks	29	29	4	4	17	17	9	9
Wald χ^2	116.6***	247.3***	17.13***	35.98***	69.31***	55.03***	276.7***	349.8***
Wooldridge test for AR1	6.095**	11.63***	55.070***	34.479***	0.779	0.795	19.192***	25.575***
Arellano-Bond test for AR1	11.80***	5.829**	3.22**	2.33**	6.03***	5.86***	6.59***	5.27***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Range-based volatility of ROA is calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance Income Composition = Revenue Concentration * Non-interest Income. Weight represents the proportion that income type represents of total revenue. Thus, Weight interest income from loans represents that proportion of total revenue that is sourced from interest income from loans. All six revenue weight measures cannot be included in the one model due to multicollinearity. Major Bank is a dummy variable representing the 4 to 6 major banks is Australia (as defined by APRA). Other Domestic banks is a dummy variable representing all non-major Australian banks. Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008.

Table 9
Weights regressions market risk measures: all periods and sub periods.

	All Periods: 2nd Quarter 2002 to 4th Quarter 2014.		2nd Quarter 2002 to 4th Quarter 2008		1st Quarter 2009 to 4th Quarter 2014	
Variables	MES5	MES5	MES5	MES5	MES5	MES5
Weight Interest income from loans	−0.00632		−0.0413***		0.0360***	
Weight banking fees		0.0537**		−0.00599		−0.264***
Weight trading and investment income		−0.0153		0.0321***		−0.0855***
Weight investment banking income		0.0185		−0.000448		0.00290
Weight other interest income		−0.201*		−0.159		−0.189*
Weight other non-interest income		0.0159***		0.0309***		−0.0440***
Capital adequacy ratio (%)	−0.0255	−0.0112	−0.00165	−0.00694	0.0745	0.0873
Growth of net loans %	−0.0181***	−0.0164***	0.00903	0.00635	0.00539	0.0143
Growth of net loans % squared	0.000171***	0.000145***	−9.25e−05	−6.33e−05	−0.00172***	−0.00155***
Bad debt charge scaled by assets %	−0.491***	−0.466***	−0.457	−0.0209	−0.412**	−0.549**
Log total assets (annual average)	0.0495	0.0231	2.162	−3.747	1.597***	1.646***
Log total assets (annual average) squared	−0.00913***	−0.00741**	−0.0738	0.0523	−0.00765	−0.0104*
Major bank	0.784***	0.700***	4.064***	2.496***	−3.429***	−3.066***
Post-2008	−4.617***	−3.908***				
2007 to 2008	−0.180	−0.0203	−0.138	−0.141		
Constant	3.376	1.925	−8.522	57.25*	−22.52***	−17.85***
Observations	425	425	241	241	184	184
Number of banks	11	11	11	11	8	8
Wald χ^2	178.3***	182.3***	157.8***	115.6***	38.28***	78.74***
Wooldridge test for AR1	70.814***	77.728***	13.084***	18.698***	50.960***	61.453***
Arellano-Bond test for AR1	13.66***	13.14***	10.01***	9.73***	8.27***	7.10***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Range-based volatility of ROA is calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance Income Composition = Revenue Concentration * Non-interest Income. Weight represents the proportion that income type represents of total revenue. Thus, Weight interest income from loans represents that proportion of total revenue that is sourced from interest income from loans. All six revenue weight measures cannot be included in the one model due to multicollinearity. Major Bank is a dummy variable representing the 4 to 6 major banks is Australia (as defined by APRA). Other Domestic banks is a dummy variable representing all non-major Australian banks. Marginal Expected Shortfall (MES) is calculated following Acharya et al. (2012). MES5 is the marginal expected shortfalls at the five per cent level. MES has been multiplied by -1 to allow consistent interpretation of estimated coefficients.

surveillance of APRA and the introduction of a deposit guarantee in 2008,[32] rather than the direct effects of the financial crisis.

It is also found that higher levels of revenue volatility are associated with increased bank holdings of capital. This indicates a degree of compensation for increased risk, possibly due to increased regulatory intervention (or potential intervention) by the prudential regulator (APRA). Further, those banks with increased revenue specialization, especially in traditional lending activities, benefit from lower revenue volatility.

The relationship between bank scale and bank risk has also been explored. It is found that the major banks have reached the size point where increased size results in increased bank risk, most likely due to the increased complexity and information asymmetry associated with large complex multi-product financial institutions. It should be noted that the relatively small number of large banks in Australia and the concentrated nature of the Australian banking system place some limitations on the applicability of this result to other financial systems without further study. When considering the revenue volatility results in the light of the systemic risk results, it is concluded that too-big-to-fail effects are apparent in Australian banking. The larger banks' observed higher levels of risk can be ascribed to the implied moral hazard effects of too-big-to-fail status. However, offsetting this effect is a decline in major bank systemic risk after the 2008 crisis. This decline could be due to the stock market viewing the major banks as less risky due to increased regulatory surveillance or due to the government guarantee of bank deposits introduced in Australian in 2008 signaling an increased likelihood of a government bailout of a major bank in times of a financial crisis.

For the other domestic banks, the scale effect is such that they are still able to experience positive benefits from risk reduction following increases in size. This result has some implications for merger policy, in that any merger involving the major banks in Australia is unlikely to generate risk reduction benefits, although other benefits that fall outside of the ambit of this study remain worthy of consideration.

It is found that trading and investment income is associated with lower revenue volatility, but this is true only for those banks with the most or least concentrated revenue portfolios prior to the 2008 crisis. After the 2008 crisis those bank benefitting from the risk reduction benefits of trading and investment activity are in the top seventy five percent of banks by revenue concentration. It was found that those banks in the lowest twenty five percent of banks by revenue concentration showed some evidence of risk increases due to trading and investment activity. It would be expected *a priori* that trading and investment income acts to increase bank risk but the evidence of this study supports the existence of some portfolio diversification benefits from this type of activity. Thus, this paper argues that an important caveat for the general findings that increased non-interest income results in increased bank risk is that this result depends on the degree of bank revenue specialization and the nature of the non-interest income. Again further studies in environments with a larger number of banks (especially listed banks) would be a valuable extension of this study.

This paper has the benefit of being able to evaluate the banks' own estimates of their internal Value at Risk (IVaR) due to exposure to market risk.[33] These bank-level details have previously

[32] The introduction of a deposit guarantee in Australia in 2008 was a response to the financial crisis. Prior to that date Australia had neither a deposit insurance scheme nor a deposit guarantee.

[33] Currently APRA does not make publicly available a list of those banks authorized under APS 116 to calculate their own IVaR. Some banks do choose to voluntarily make this information public in their annual reports.

Table 10
Internal measures of market exposure: revenue weights: all periods and sub periods.

	All periods: 2nd Quarter 2002 to 4th Quarter 2014.		2nd Quarter 2002 to 4th Quarter 2008.		1st Quarter 2009 to 4th Quarter 2014.	
Variables	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av	IVAR60av
Weight Interest income from loans	−0.000743*		−4.59e−10		−0.00237***	
Weight Banking Fees		0.00552**		−2.48e−09		−0.000576
Weight trading and investment income		0.00502***		2.17e−09*		0.00771***
Weight investment banking income		0.000732		5.24e−09*		0.00549*
Weight other interest income		0.00247		6.79e−09		0.00546***
Weight other non-interest income		0.00163***		−1.05e−09		0.000586
Capital adequacy ratio (%)	−0.00131	−0.00343**	−1.16e−09	−8.97e−10	−0.00379***	0.00335
Growth of Net Loans %	0.000282	0.000236	1.02e−09	1.43e−09	−6.78e−05	−0.000285
Growth of net loans % squared	−2.53e−05	−2.21e−05	−4.53e−11	−5.65e−11	−0.000145***	−4.08e−05
Bad debt charge scaled by assets %	−0.00605	−0.0120	−4.36e−08*	−3.00e−08	−0.0145*	−0.0122
Log total assets (annual average)	0.0346**	0.0195	2.35e−06***	5.66e-07	0.0928***	0.0331
Log total assets (annual average) squared	−0.000305	−6.03e−06	−4.50e−08***	−1.05e−08	0.000436	−0.000140
Major bank	−0.0356	−0.0330	−3.44e−07***	−1.68e−07**	−0.340***	−0.0526
Post-2008	0.410**	0.387**				
2007 to 2008	−0.00109	−0.00259	−2.44e−08***	−2.71e−08***		
Constant	−0.604*	−0.565*	−3.02e−05***	−7.38e−06	−0.664***	−0.420*
Observations	315	315	150	150	165	165
Number of banks	8	8	7	7	7	7
Wald χ^2	164.1***	270.4***	58.73***	85.14***	263.3***	401.9***
Wooldridge test for AR1	27.258***	29.846***	51.223***	46.642***	159.671***	60.408***
Arellano-Bond test for AR1	13.57***	10.31***	7.44***	6.65***	6.96***	4.51***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$. Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Range-based volatility of ROA is calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance Income Composition = Revenue Concentration * Non-interest Income. Weight represents the proportion that income type represents of total revenue. Thus, Weight interest income from loans represents that proportion of total revenue that is sourced from interest income from loans. All six revenue weight measures cannot be included in the one model due to multicollinearity. Major Bank is a dummy variable representing the 4 to 6 major banks is Australia (as defined by APRA). Other Domestic banks is a dummy variable representing all non-major Australian banks. IVaR60 is the bank specific internal estimate of Value at Risk due to market risk, averaged over the previous 60 trading days, scaled by equity.

Table 11
Sample stratification by revenue concentration.

Panel A: All periods: 2nd Quarter 2002 to 4th Quarter 2014.

Variables	25% of banks with most concentrated revenue		Median 50% of banks by revenue concentration		25% of banks with least concentrated revenue	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Non-interest Income % of revenue	0.00629***		0.0120***		0.00470	
Covariance (revenue concentration, non-interest income)		2.12e−06***		3.53e−06***		3.80e−06***
Capital adequacy ratio (%)	0.00162	−0.0294*	0.0263***	0.0262***	0.00754**	0.00844**
Bad debt charge scaled by assets %	0.347***	0.0973	0.269***	0.239***	−0.0214	0.0272
Growth of net loans %	−0.00333***	−0.00700**	0.000921	0.00120	−1.33e−05	0.000283
Growth of net loans % squared	5.04e−05***	4.79e−05***	−3.86e−05**	−4.09e−05**	0.000114**	0.000124**
Log total assets (annual average)	−0.0201	−0.119*	0.0417*	0.0376*	0.00101	−0.0391
Log total assets (annual average) squared	−0.000821	0.00131	4.55e−05	0.000259	−0.00142	−0.000330
Major bank	−0.0583	−0.227*	0.396***	0.327***	0.0149	0.0160
Other domestic bank	−0.186***	−0.169**	0.0976	0.0379	−0.0575	−0.152
Post-2008	−0.734***	−1.102**	0.359	0.417*	−1.214**	−1.130*
2007 to 2008	−0.270***	−0.290***	0.0194	0.0227	0.254**	0.354***
Constant	0.257	1.899*	−2.008***	−2.106***	0.664	0.623
Observations	326	247	510	510	248	248
Number of banks	37	16	28	28	14	14
Wald χ^2	7833***	74.11***	380.3***	415.7***	133.6***	121.5***
Wooldridge test for AR1	12.970**	2.467	24.835***	24.798***	2.465	2.254
Arellano-Bond test for AR1	7.11***	8.99***	12.03***	12.27***	7.47***	7.76***

Panel B: sample stratification by revenue concentration: 2nd Quarter 2002 to 4th Quarter 2008.

Variables	25% of banks with most concentrated revenue		Median 50% of banks by revenue concentration		25% of banks with least concentrated revenue	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Non-interest Income % of revenue	0.00620***		0.0193***		−0.00566	
Covariance (revenue concentration, non-interest income)		2.62e-−06***		3.74e−06***		−2.98e−07
Capital adequacy ratio (%)	−0.00617	−0.0432	0.0120***	0.0136***	0.0160***	0.0165***
Bad debt charge scaled by assets %	0.516**	0.295	0.552**	0.427**	0.122	0.0639
Growth of net loans %	−0.0112***	−0.00574	−0.00520***	−0.00503***	0.00227	0.00267
Growth of net loans % squared	8.22e−05***	3.08e−05	4.01e−05**	3.83e−05**	8.23e−05	5.91e−05
Log total assets (annual average)	−0.827**	0.121	−0.929**	−0.845**	−0.635	−1.096
Log total assets (annual average) squared	0.0159*	−0.00500	0.0177**	0.0170**	0.0206	0.0311
Major bank	0.116	−0.113	1.076***	0.877***	−1.694**	−1.819**
Other domestic bank	0.366***	0.463***	0.547***	0.442***	−0.343	−0.476
2007 to 2008	−0.189**	−0.131	0.0587	0.0385	0.0145	0.0503
Constant	9.867**	−0.269	10.61**	9.088*	3.806	8.656
Observations	175	122	253	253	125	125
Number of banks	27	9	17	17	11	11
Wald χ^2	401.9***	1662***	451.9***	366.5***	71.04***	56.45***
Wooldridge test for AR1	5.773**	0.884	11.557***	11.209***	0.090	0.011
Arellano-Bond test for AR1	5.76***	4.53***	6.54***	6.59***	5.34***	5.11**

(*continued on next page*)

Table 11 (*continued*)

Panel C: sample stratification by revenue concentration: 1st Quarter 2009 to 4th Quarter 2014.

Variables	25% of banks with most concentrated revenue		Median 50% of banks by revenue concentration		25% of banks with least concentrated revenue	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Non-interest Income % of revenue	−0.00948*		−0.00930***		0.00248	
Covariance (revenue concentration, non-interest income)		1.56e−06***		−1.29e−06**		7.15e−07
Capital adequacy ratio (%)	0.0130	0.0437***	0.0705***	0.0676***	−0.0141	−0.0139
Bad debt charge scaled by assets %	0.209	0.113	0.528***	0.508***	−0.0666	−0.120
Growth of net loans %	−0.0278***	−0.0256***	−0.00519	−0.00473	−0.00485	−0.00458
Growth of net loans % squared	−4.64e−05	−0.000155	−0.000248***	−0.000235***	3.28e−05	3.36e−05
Log total assets (annual average)	0.174**	0.0459	0.184***	0.178***	−0.246**	−0.250**
Log total assets (annual average) squared	−0.00982**	−0.00317	−0.000817	−0.000849	0.00577	0.00595
Major bank	−0.151	0.537**	0.243	0.237	0.111	0.109
Other domestic bank	−0.282***	−0.192**	0.341***	0.324***	−0.237***	−0.243**
Constant	−1.445***	−1.355**	−3.451***	−3.359***	1.745**	1.760**
Observations	152	126	251	251	126	126
Number of banks	20	11	22	22	9	9
Wald χ^2	47.79***	354.7***	300.8***	279***	73.77***	61.33***
Wooldridge test for AR1	9.180**	4.602*	18.013***	17.334***	4.591*	5.859**
Arellano-Bond test for AR1	2.85***	5.02***	6.91***	6.74***	3.34***	3.20***

Standard errors in parentheses; *** $p<0.01$, ** $p<0.05$, * $p<0.1$ Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1. Range-based volatility of ROA is calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance Income Composition = Revenue Concentration * Non-interest Income. Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008. In the interests of parsimony only the results for range volatility of return on assets after tax are shown. Major Banks are the 4 to 6 major banks is Australia (as defined by APRA). The Other Domestic banks are all non-major Australian banks. The sample is stratified by the sample-specific HHI index of revenue concentration.

Table 12
Sample stratification by revenue concentration: impact of revenue weights.

Panel A: all periods: 2nd Quarter 2002 to 4th Quarter 2014.

Variables	25% of banks with most concentrated revenue		Median 50% of banks by revenue concentration		25% of banks with least concentrated revenue	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Weight Interest income from loans		−0.0130**		−0.00484		0.000196
Weight banking fees	−0.0499***		0.0256***		−0.00344	
Weight Trading and Investment Income	−0.0560***		−0.0247***		−0.00600	
Weight Investment Banking Income	0.0262***		0.0288***		0.0235**	
Weight other interest income	−0.0371**		0.0214		0.0222	
Weight other non-interest Income	−0.0219**		0.00597*		0.00684	
Capital adequacy ratio (%)	−0.0130	−0.0314**	0.0281***	0.0234***	0.00642	0.00778**
Growth of net loans %	−0.00663***	−0.00813***	0.000588	−3.63e−05	0.000538	−0.000354
Growth of Net Loans % squared	3.42e−05***	6.55e−05***	−3.60e−05**	−2.54e−05	0.000105*	0.000127**
Bad debt charge scaled by assets %	0.167	0.0969	0.199**	0.253***	−0.0351	0.0384
Log total assets (annual average)	−0.171***	−0.0706	0.0253	0.0405*	−0.0855	−0.0135
Log total assets (annual average) squared	0.00314**	−0.00107	0.000361	−0.000398	0.00149	−0.00133
Major bank	−0.218	0.0232	0.318***	0.591***	−0.0205	0.0418
Other Domestic Bank	−0.0835	−0.105	−0.140**	0.216**	−0.360	0.144
Post-2008	−0.884***	−1.489***	0.365	0.0841	−0.765	−1.421**
2007 to 2008	−0.292***	−0.293***	0.122**	−0.0432	0.332***	0.237*
Constant	2.573***	3.203***	−1.522***	−1.243**	1.001	1.098
Observations	247	247	510	510	248	248
Number of banks	16	16	28	28	14	14
Wald χ^2	1790***	89.10***	619***	300.3***	128.5***	162.8***
Wooldridge test for AR1	2.254	2.837	24.000***	24.843***	1.951	2.260
Arellano-Bond test for AR1	6.42***	8.85***	11.63***	12.16***	7.09***	7.95***

Panel B: sample stratification by revenue concentration: impact of revenue weights: 2nd Quarter 2002 to 4th Quarter 2008.

Variables	25% of banks with most concentrated revenue		Median 50% of banks by revenue concentration		25% of banks with least concentrated revenue	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Weight Interest income from loans		−0.0130***		−0.0210***		0.0116
Weight banking fees	0.0772**		0.0282***		−0.0723**	
Weight trading and investment income	−0.0674***		−0.00424		−0.0403***	
Weight investment banking income	0.0119**		0.0334***		−0.0537***	
Weight other interest income	−0.0575*		−0.213***		−0.0638*	
Weight other non-interest income	0.0375		0.0178***		−0.0123	
Capital adequacy ratio (%)	−0.0385	−0.0532*	0.0219***	0.0120**	0.0117*	0.0156***
Growth of net loans %	−0.00125	0.00304	−0.00335**	−0.00497***	−0.000767	0.00163
Growth of net loans % squared	1.97e−05	6.65e−06	1.10e−05	3.82e−05**	0.000120*	8.00e−05
Bad debt charge scaled by assets %	0.235	0.286	0.213	0.479**	−0.0845	−0.0134
Log total assets (annual average)	−3.005***	0.0578	−0.357	−0.784**	−4.551**	−1.453
Log total assets (annual average) squared	0.0687***	−0.00591	0.00747	0.0145**	0.0973**	0.0384
Major Bank	−1.469***	0.203	0.586***	1.263***	−1.914**	−2.136***
Other Domestic Bank	0.556***	0.381***	0.112	0.766***	1.351	−0.371
2007 to 2008	−0.221***	−0.112	0.108**	−0.0211	−0.0522	0.0546
Constant	33.13**	2.887	3.066	10.67***	55.29**	12.63
Observations	122	122	253	253	125	125
Number of banks	9	9	17	17	11	11
Wald χ^2	1099***	352.5***	1014***	414***	89.21***	82.65***
Wooldridge test for AR1	0.741	0.887	12.421***	11.353***	0.044	0.016
Arellano-Bond test for AR1	2.86***	4.96***	6.16***	6.66***	3.85***	5.19***

(*continued on next page*)

Table 12 (*continued*)

Panel C: sample stratification by revenue concentration: impact of revenue weights: 1st Quarter 2009 to 4th Quarter 2014.

Variables	25% of banks with most concentrated revenue		Median 50% of banks by revenue concentration		25% of banks with least concentrated revenue	
	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA	Range-based volatility of ROA
Weight Interest income from loans		0.0142		0.00882***		−0.000397
Weight banking fees	−0.0585***		0.0235*		0.0299	
Weight trading and investment income	−0.0586***		−0.0393***		−0.00890	
Weight investment banking income	0.0557		−0.0145		0.0191	
Weight other interest income	−0.0258*		−0.726***		0.00259	
Weight other non-interest income	0.0322		−0.00589**		0.00439	
Capital adequacy ratio (%)	0.00529	0.0215	0.0175*	0.0633***	−0.0109	−0.0120
Growth of net loans %	−0.0306***	−0.0277***	−0.00473	−0.00496	−0.00283	−0.00392
Growth of net loans % squared	−0.000159	−9.75e−05	−6.36e−05	−0.000209***	−5.91e−05	2.73e−05
Bad debt charge scaled by assets %	0.00342	0.122	0.348***	0.548***	−0.104	−0.0763
Log total assets (annual average)	−0.111	0.0569	0.0110	0.166***	−0.270*	−0.227*
Log total assets (annual average) squared	0.000660	−0.00531*	0.000138	−0.00110	0.00919	0.00557
Major bank	2.122**	−0.172	0.453**	0.286**	0.0105	0.0713
Other domestic bank	−0.182	−0.159*	−0.105	0.298***	−0.105	−0.238
Constant	1.139	−2.107*	−0.545	−3.910***	1.438	1.626*
Observations	126	126	251	251	126	126
Number of banks	11	11	22	22	9	9
Wald χ^2	461***	65.81***	404.74***	480.23***	51.29***	47.74***
Wooldridge test for AR1	5.492***	5.749**	18.072***	16.877***	11.093**	4.681*
Arellano-Bond test for AR1	3.21***	4.58***	6.14***	6.70***	3.12***	3.16***

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Model estimated using Feasible GLS with panel specific corrections for heteroskedasticity and AR1.

Range-based volatility of ROA and Profits are calculated following Alizadeh et al. (2002) as log (high value – low value). Covariance Income Composition = Revenue Concentration * Non-interest Income. Weight represents the proportion that income type represents of total revenue. Thus, Weight interest income from loans represents that proportion of total revenue that is sourced from interest income from loans. Post-2008 is a dummy variable representing all observations after the 4th Quarter 2008. 2007 to 2008 is a dummy variable representing 1st Quarter 2007 to 4th Quarter 2008. All six revenue weight measure cannot be included in the one model due to multicollinearity. Major Banks are the 4 to 6 major banks is Australia (as defined by APRA). The Other Domestic banks are all non-major Australian banks. The sample is stratified by the sample-specific HHI index of revenue concentration.

been considered highly confidential. It is found that those banks with higher levels of IVaR are more active in trading and investment activity and the provision of investment banking services, with limited additional explanatory power resulting from the inclusion of additional variables traditionally used when modeling bank risk. These results should be treated as preliminary due to the small degrees of freedom available to this study. Thus, future study into this issue in a setting where more observations are available would be a valuable contribution to this stream of literature.

It has been found that the relationship between bank loan growth and bank risk is conditional upon the degree of bank revenue concentration. For those banks with more concentrated revenue portfolios, loan growth is risk increasing, while for those banks with the median level of revenue concentration loan growth is risk reducing. For those banks in the bottom quartile of revenue concentration, no relationship between bank risk and loan growth was established.

An important policy implication of these results is that those banks which are more specialized and have more focused portfolios are most likely to be of lower risk. However, this conclusion should be accompanied by the caveat that those banks with higher levels of non-interest income will also be riskier ceteris paribus. Thus, a trade-off between these two effects must be monitored. Finally, when considering the risk of any individual banks, peer banks must be carefully chosen, and in some cases the most appropriate peers will not always be drawn from the same institutional sub-grouping.

References

Acharya, Viral, Engle, Robert, Richardson, Matthew, 2012. Capital shortfall: a new approach to ranking and regulating systemic risks. American Economic Review 102, 59–94.

Acharya, Viral, Hasan, Iftekhar, Saunders, Anthony, 2006. Should banks be diversified? Evidence from individual bank loan portfolios. Journal of Business 79, 1355–1412.

Measuring Systemic Risk, FRB of Cleveland Working Paper No. 10-02. Available at SSRN: Acharya, Viral, Pedersen, Lasse, Philippon, Thomas, Richardson, Matthew, 2010. http://ssrn.com/abstract=1595075 .

Alizadeh, Sassan, Brandt, Michael, Diebold, Francis, 2002. Range-based estimation of stochastic volatility models. Journal of Finance LVII, 1047–1091.

Allen, David, Powell, Robert, 2012. The fluctuating default risk of Australian banks. Australian Journal of Management 37, 297–325.

Allen, Franklin, Santomero, AnthonyM., 2001. What do financial intermediaries do? Journal of Banking and Finance 25, 271–294.

Arellano, Manual, Bover, Olympia, 1995. Another look at the instrumental variables estimation of error-components models. Journal of Econometrics 68, 29–51.

Arellano, Manuel, Bond, Stephen, 1991. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The Review of Economic Studies 58, 277–297.

Australian Prudential Regulation Authority, 2012. The impact of the Basel III Capital reforms in Australia. Australian Prudential Regulation Authority. APRA Insight, Sydney, Australia.

Baltagi, Badi, 2008. Econometric Analysis of Panel Data. John Wiley and Sons.

Berger, Allen N., Hasan, Iftekhar, Zhou, Mingming, 2010. The effects of focus versus diversification on bank performance: evidence from Chinese banks. Journal of Banking and Finance 34, 1417–1435.

Berger, Philip, Ofek, Eli, 1996. Bustup takeovers of value-destroying diversified firms. The Journal of Finance 51, 1175–1200.

Blundell, Richard, Bond, Stephen, 1998. Initial conditions and moment restrictions in dynamic panel data models. Journal of Econometrics 87, 11–143.

Brunnermeier, Markus, Dong, Gang, Palia, Darius, 2012. Banks' non-interest income and systemic risk, AFA 2012 Chicago Meetings Paper. Available at SSRN: http://ssrn.com/abstract=1786738 or http://dx.doi.org/10.2139/ssrn.1786738.

Clarke, Timothy, Dick, Astrid, Hirtle, Beverly, Stiroh, Kevin, Williams, Robard, 2007. The role of retail banking in the U.S. banking industry: risk return, and industry structure. FRBNY Economic Policy Review 39 (3), 39–56.

De Haan, Jakob, Poghosyan, Tigran, 2012. Bank size, market concentration, and bank earnings volatility in the US. Journal of International Financial Markets, Institutions and Money 22, 35–54.

DeYoung, R., Rice, T., 2004. Non-interest income and financial performance at U.S. commercial banks. The Financial Review 39, 101–127.

DeYoung, R., Roland, K., 2001. Product mix and earnings volatility of commercial banks: evidence from a degree of total leverage model. Journal of Financial Intermediation 10, 54–84.

DeYoung, Robert, Torna, Gokhan, 2013. Nontraditional banking activities and bank failures during the financial crisis. Journal of Banking and Finance 22, 397–421.

Diamond, Douglas, 1984. Financial intermediation and delegated monitoring. Review of Economic Studies 59, 393–414.

Elyasiani, Elyas, Wang, Yong, 2008. Non-interest income diversification and information asymmetry of bank holding companies. In: Financial Management Association Annual Meeting. Grapevine, Texas, USA.

Engle, Robert, Moshirian, Fariborz, Zahgal, Sidharth, Zhang, Bohui, 2014. Banks non-interest income and global financial stability. In: Centre for International Finance and regulation. Sydney, Australia.

Esho, Neil, Kaufman, Paul, Sharpe, Ian, 2005. Diversification, fee income and credit union risk. Journal of Financial Services Research 27, 259–281.

Jensen, Michael, 1986. Agency costs of free cash flow, corporate finance, and takeovers. American Economic Review 76, 323–329.

Jorion, Phillippe, 2000. Value at Risk: The New Benchmark for Managing Financial Risk. McGraw-Hill.

Kaufman, George, 2014. Too big to fail in banking: what does it mean? Journal of Financial Stability 13, 214–223.

Kwan, Simon, Eisenbeis, Robert, 1997. Bank risk, capitalization, and operating efficiency. Journal of Financial Services Research 12, 117–131.

Laeven, Luc, Levine, Ross, 2007. Is there a diversification discount in financial conglomerates? Journal of Financial Economics 85, 331–367.

Lepetit, Laetitia, Nys, Emmanualle, Rous, Phillippe, Tarazi, Amine, 2008. The expansion of services in European banking: implications for loan pricing and interest margins. Journal of Banking and Finance 32, 2325–2335.

McAleer, Michael, 2009. The ten commandments for optimizing value-at-risk and daily capital charges. Journal of Economic Surveys 23, 831–849.

Merton, RobertC., 1977. An analytic derivation of the cost of deposit insurance and loan guarantees: an application of modern option pricing theory. Journal of Banking and Finance 1, 3–11.

Nguyen, James, 2012. The relationship between net interest margin and non-interest income using a system estimation approach. Journal of Banking and Finance 36, 2429–2437.

Parkinson, Michael, 1980. The extreme value method for estimating the variance of the rate of return. Journal of Business 53, 61–65.

Ramakrishnan, Ram, Thakor, Anjan, 1984. Information reliability and a theory of financial intermediation. Review of Economic Studies 51, 415–432.

Roodman, David, 2009. How to do xtabond2: an introduction to difference and system GMM in Stata. Stata Journal 9, 86–136.

Saunders, Anthony, Strock, Elizabeth, Travlos, Nickolaos, 1990. Ownership control, regulation and bank risk-taking. The Journal of Finance 45, 643–654.

Saunders, Anthony, Walter, Ingo, 1994. Universal Banking in the United States: What could we gain? What could we lose?. Oxford University Press, New York.

Schmid, Markus, Walter, Ingo, 2009. Do financial conglomerates create or destroy economic value? Journal of Financial Intermediation 18, 193–216.

Stiroh, Kevin, 2006. A portfolio view of banking with interest and non interest income. Journal of Money, Credit and Banking 28, 1351–1361.

Stiroh, Kevin, Rumble, Adrienne, 2006. The dark side of diversification: the case of US financial holding companies. Journal of Banking and Finance 30, 2131–2161.

Sturm, Jan-Egbert, Williams, Barry, 2004. Foreign banks entry, deregulation and bank efficiency: lessons from the Australian experience. Journal of Banking and Finance 28, 1775–1799.

Sturm, Jan-Egbert, Williams, Barry, 2008. Characteristics determining the efficiency of foreign banks in Australia. Journal of Banking and Finance 32, 2346–2360.

van Lelyveld, Iman, Knot, Klass, 2009. Do financial conglomerates create or destroy value? Evidence for the EU. Journal of Banking and Finance 33, 2312–2321.

Williams, Barry, 1998. Factors affecting the performance of foreign-owned banks in Australia: a cross-sectional study. Journal of Banking and Finance 22, 197–219.

Williams, Barry, 2007. Factors determining net interest margins in Australia: domestic and foreign banks. Financial Markets, Institutions & Instruments 16, 145–165.

Williams, Barry, Prather, Laurie, 2010. Bank risk and return: the impact of bank non-interest income. International Journal of Managerial Finance 6, 220–244.

Williams, Barry, Rajaguru, Gulasekaran, 2013. The Chicken or the Egg? The trade-off between bank non-interest income and net interest margins. Australian Journal of Management 38, 99–123.

Wooldridge, Jeffrey, 2010. Econometric Analysis of Cross Section and Panel Data. MIT Press, Cambridge, Massachusets.